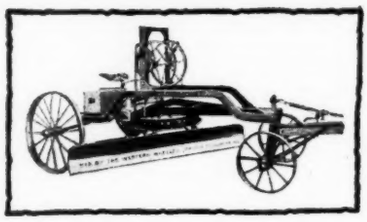
JAN 30 1925

# PUBLIC WORKS

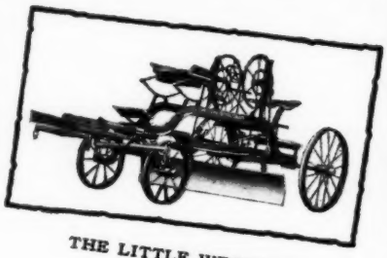
CITY COUNTY STATE


JANUARY, 1925

THE WESTERN MIDGET GRADER
Weight: 1000 pounds
Blade Length: 5 or 6 feet



WESTERN PATROL GRADERS
Weight of No. 1—1480 pounds
Blade Length: 8 feet
Weight of No. 2: 1000 pounds
Blade Length: 8 feet



THE LITTLE WESTERN GRADER
Weight: 1450 pounds
Blade Length: 6 feet

# A-W GRADERS

Below are mentioned, the four things that are the best possible advance guarantee of satisfactory service from any piece of road machinery. **Let us see how A-W Graders meet the test.**

### SCIENTIFIC DESIGN?

The first Austin and Western graders were made over 40 years ago. In design and construction they are not only scientific, but above all things thoroughly practical, because they embody all the worth-while features that these years of experience have developed, and no untried theories that have not stood the test of time.

### RUGGEDNESS?

The second Western grader, made and sold in 1879, is still in active service.

### QUANTITY PRODUCTION?

Thousands of Austin and Western graders of all sizes are in daily use in practically every country in the world.

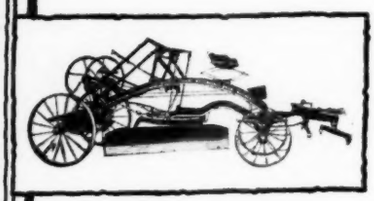
### A COMPLETE LINE?

A-W graders range in weight from 1,000 to 11,500 pounds; and in blade length, from 5 feet to 12 feet.

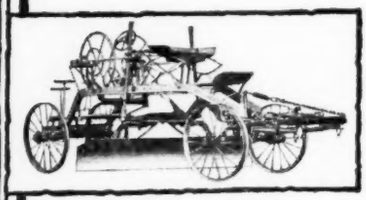
Whether your work be the construction of a new road through the roughest kind of country; the efficient, economical maintenance of an earth or gravel road; or "just grading"; you will find on this page a model as good as made-to-order for you. General Catalog No. 24 tells all about these graders—Write for a copy.

## The Austin-Western Road Machinery Co.

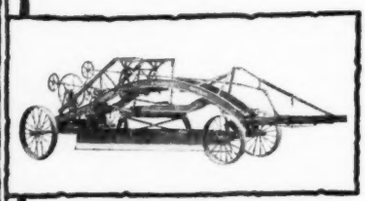
CHICAGO :: ILLINOIS



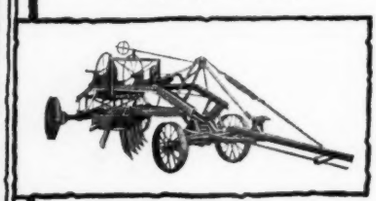
THE AUSTIN STANDARD GRADER
Weight: 2500 pounds
Blade Length: 7 feet



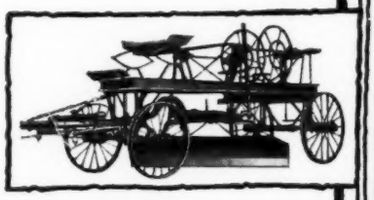
THE AURORA STANDARD AND SPECIAL GRADERS
Weight of Standard: 2925 pounds.
Blade Length: 8 feet
Weight of Special: 3300 pounds.
Blade Length: 7 or 8 feet



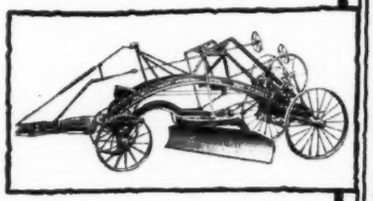
THE AUSTIN MAMMOTH JUNIOR AND SENIOR GRADERS
Weight of Junior: 6750 pounds.
Blade Length: 10 feet
Weight of Senior: 7600 pounds.
Blade Length: 12 feet



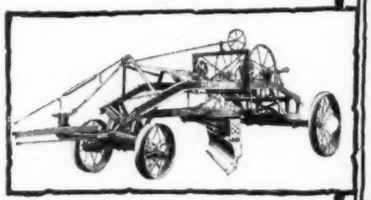
THE WESTERN No. 14 SCARIFIER
Weight: 11,500 pounds



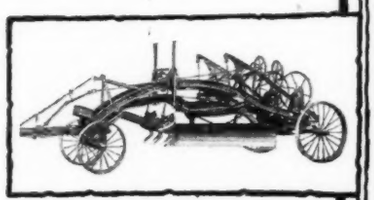
THE WESTERN STANDARD AND SPECIAL GRADERS
Weight of Standard: 2675 pounds.
Blade Length: 7 feet
Weight of Special: 2900 pounds.
Blade Length: 7 feet



THE AUSTIN GIANT GRADER
Weight: 4150 pounds
Blade Length: 8 feet



THE WESTERN No. 20 GRADER
Weight: 11,500 pounds
Blade Length: 12 feet



THE AUSTIN JUNIOR AND SENIOR RIP-SNORTERS
Weight of Junior: 5000 pounds.
Blade Length: 8 feet
Weight of Senior: 9300 pounds.
Blade Length: 9 feet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JANUARY, 1925

# PUBLIC WORKS

CITY COUNTY STATE

A Combination of "MUNICIPAL JOURNAL" and "CONTRACTING"

Vol. 56 JANUARY, 1925 No. 1


# Spavinaw Water Supply Project

**Tulsa, Oklahoma, goes fifty-five miles for a water supply, builds a dam two-thirds of a mile long, and carries the pipe line through a two-mile tunnel, under five railroads and several streams**

By W. R. Holway, Chief Engineer

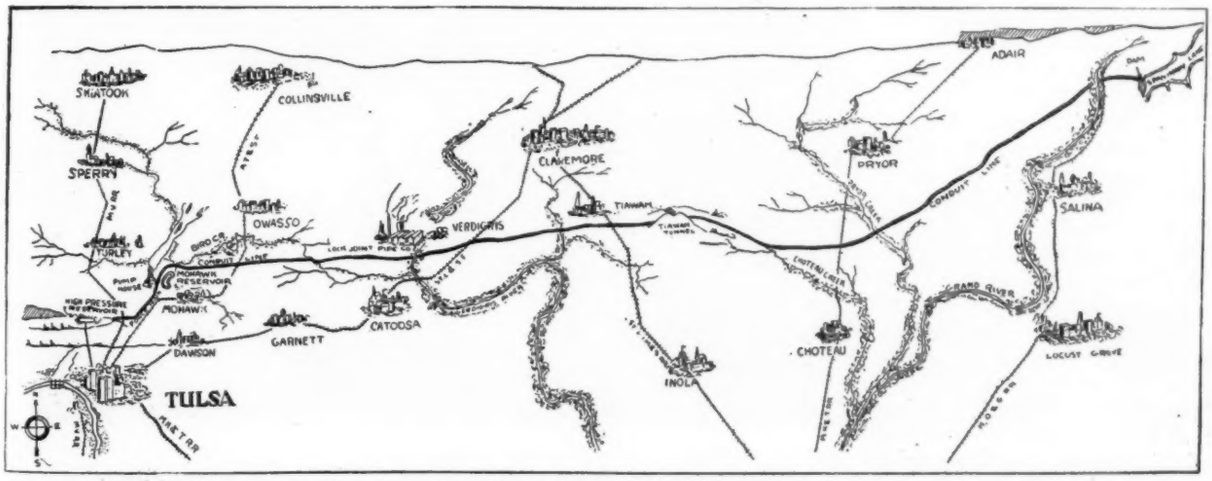
The City of Tulsa, Oklahoma, has just completed a big water project, connecting the city with her new source of supply, the Spavinaw Creek in the foothills of the Ozarks, sixty miles to the northeast. Across this creek the city has built a dam 55 feet high, with solid masonry spillway 800 feet long, concrete non-overflow section 150 feet long, and earthen embankment with concrete core-wall 2600 feet in length. This structure impounds approximately twenty billion gallons of water, clear and soft, abundant in quantity, and of a quality amply satisfactory for every use, industrial or domestic, forming a beautiful lake, six miles long and covering 1800 acres.

The dam lies between rugged, wooded hills, where the soil and the location is peculiarly fitted for a reservoir site. A limestone ledge furnishes perfect foundation conditions, and from gravel beds down the river came much of the material for the concrete aggregate. A washing and screening plant prepared this material for use, and about 70% of the sand and all of the stone was secured in this way. The remainder was shipped in over the Spavinaw Railroad.

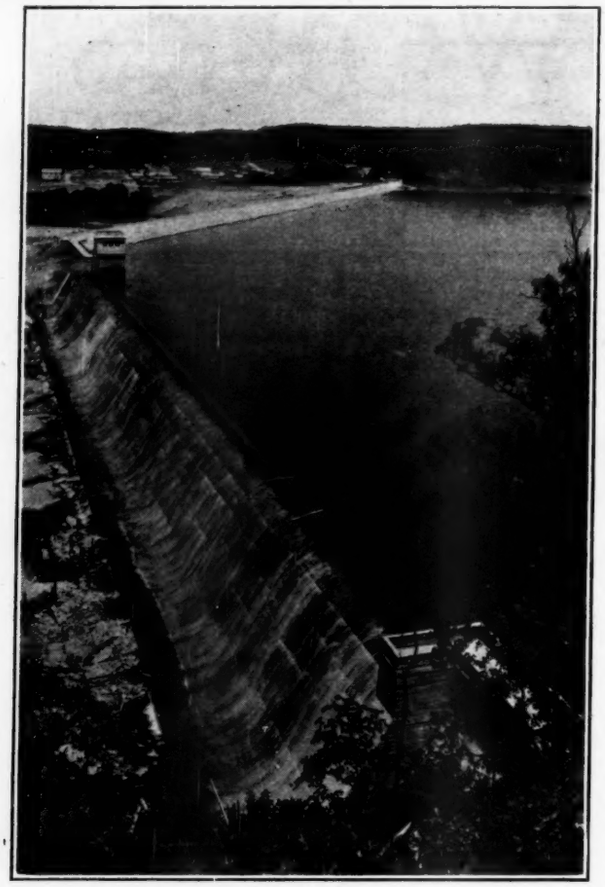
The concrete was mixed, handled, and poured by an Insley tower and chuting system, augmented by a movable tower and an auxiliary plant on the other bank of the stream. Most of the plums were secured from the site of the dam and deposited by a Clyde derrick and a cableway. The construction of the dam occupied 16 months and the cost was approximately $845,000. The contractor was the Standard Paving Company of Tulsa.

This company also built the Tiawah Tunnel, which lies midway of the 55-mile conduit, and which was necessary to maintain the gravity flow throughout the line. Here the cost of tunnelling the ridge was balanced against the cost of a longer pipeline at lower levels and the tunnel found cheaper. The city planned for the future in designing this tunnel, nearly two miles long with its approaches, making it seven feet in diameter, giving it capacity sufficient to carry three times as much water as the rest of the conduit. Tulsa may have to build additional pipelines at some future time, but probably not another tunnel.

This tunnel was excavated from four headings, through dense shale, and was lined with six-inch




TULSA AND ADJACENT COUNTRY, SPAVINAW LAKE, MOHAWK RESERVOIR AND ROUTE OF PIPE LINE.



SPAVINAW DAM

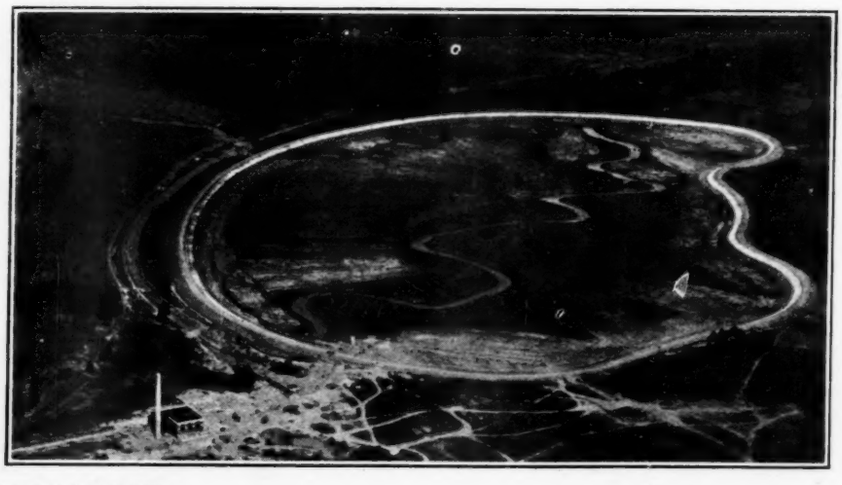
concrete to make the interior smooth and tight. This lining was placed by a pneumatic concrete mixer and was shot into the movable forms under 100 pounds pressure. The approaches to the tunnel were of monolithic concrete construction, 84 inches in diameter, and built in deep open cuts. The total cost was $370,000.

Mohawk Reservoir, five miles from Tulsa, was an interesting earthwork job. The engineers, in making their surveys in search of the gravity line, saw that Bird Creek bottoms north of the city near Mohawk are lower than the banks of the Arkansas river on which Tulsa is built. The difference in elevation between these bottoms and Spavinaw Dam is approximately 90 feet. This difference in head made it possible to bring the water by gravity the 55 miles to Mohawk. Here was constructed a storage reservoir and a pumping station to lift the water to the city. A small stream in the bottoms was diverted by a dam and levee, and in the old bed of this stream elevating grader outfits stripped the soil and earth and built a circular embankment, a mile and a half long and 18 feet high. This embankment, after standing some months for settlement, was paved on the inside with 4-inch concrete to protect the bank from wave action. The cost of the earthwork construction was $122,000 and of the paving was $50,000.

This reservoir has a capacity of 500,000,000 gallons, and serves merely as an emergency supply in case of pipeline breaks, or a short period of cloudy water due to floods at Spavinaw. The pumps take the water directly from the conduit, and the surplus only flows into Mohawk reservoir. At present this surplus is more than two-thirds the amount the conduit supplies, for this whole system was built with an eye to the rapid future growth of the city.

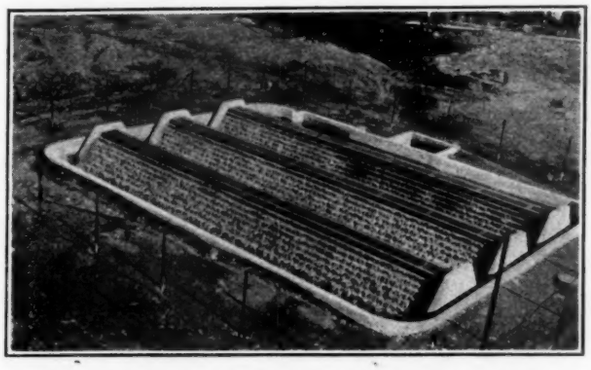
The pumping station, built on the banks of this reservoir, is a thoroughly modern plant. Here, as at the dam, great care was taken in the design and construction from an architectural standpoint, since these two structures are the only ones on the entire project which show above the ground. The station was built by the E. J. Merkle Contracting Company of Kansas City at a cost of $372,000. The water flows through screens into a receiving well, where it is chlorinated, and then to the aerator of concrete step design. In the pumping station are two 12,000,000-gallon De Lavel turbine-driven pumps which lift the water through four miles of 30-inch steel force main to the high service reservoir on a hill just north of the city. These pumps operate against a 350-foot head. Two 300 h.p. water tube boilers furnish the steam. These boilers are equipped to use either gas, oil, or coal. For reserve pumping equipment it is planned to install at this station a 12,000,000 gallon Allis-Chalmers cross compound crank and flywheel pumping engine, which has been in use at the old plant only about four years.

The high service reservoir, into which the water is pumped, is constructed of reinforced concrete and gunite, is circular in shape, and is built almost entirely in sandstone excavation and covered with a concrete flat slab supported on concrete columns. The capacity is 10,000,000 gallons. The Traylor-Dewey Company of Allentown, Pa., built this reservoir at a cost of $160,000.



Copyright by Ed Miller

AEROPLANE VIEW OF MOHAWK RESERVOIR BEFORE FILLING.
Pumping station and receiving well structures in foreground. Backfill over pipe line at left of reservoir.



VIEW OF AERATOR FROM TOP OF PUMPING STATION.

To carry the water into the city, approximately 10,000 feet of 30 and 39-inch cast iron mains were laid as a part of this project.

### THE GRAVITY CONDUIT

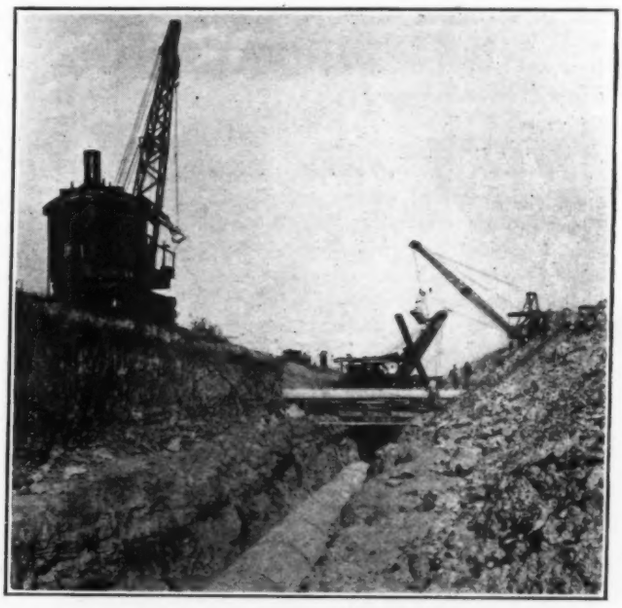
The major work was the construction of the big gravity conduit from Spavinaw Lake to Mohawk reservoir. The cost of this part of the work was over $4,000,000, or more than half the cost of the whole work. Under this contract 28 miles of 60-inch and 25 miles of 54-inch pipe were laid, the difference in size being due to the fact that the steeper gradient west of the tunnel allowed smaller pipe to be used. The drop for the 60-inch is about one foot to the mile; for the 54-inch it is approximately 1.8 feet per mile. Because of the fact that the difference in elevation between the surface of Spavinaw Lake and the surface of Mohawk reservoir is only 75 feet, a pipe had to be chosen in which the friction losses would be very small, and the questions of cost and of permanency also had to be considered. The pipe chosen was precast, reinforced, concrete pipe. In connection with the manufacture and laying of this pipe, a standard gauge railroad had to be built for the transportation of the pipe, there were various difficult excavation problems to be solved, five railroads and ten good-sized streams to be crossed. In October, 1922, this contract was let to the Walbridge-Aldinger Company of Detroit, with the Lock Joint Pipe Company of New York sub-letting the manufacture and laying of the pipe.

It was decided, because of accessibility to supplies, to make all of the pipe at Verdigris, Oklahoma, a tank town on the Frisco Railroad twenty miles east of Tulsa. Here a 40-acre tract of land was leased. In 17 months the Lock Joint Pipe Company erected their mammoth plant and manufactured 53 miles of pipe, a splendid accomplishment.

The work of excavating and back-filling the trench, of constructing the railroad and transporting the pipe did not move along so smoothly. Very bad and unusual weather conditions were encountered. The Oklahoma rivers with their high banks are treacherous in flood times, and many a bridge was washed away and lengths of track disappeared in the mud. Differences of opinion concerning classification and methods of work developed, and in January, 1924, the contractors abandoned their contract. The pipe manufacturers agreed to contract with the city and the Water Commission took the work over almost immediately and carried it on to a successful finish under the direct supervision of their engineer, W. R. Holway of Tulsa.

The work was pushed night and day along the whole line and when, in October, almost two years to a day since the first contracts were let, the last pipe was lowered into position, the city of Tulsa congratulated herself on performing a good job of construction. When the line was tested for leakage, it was found that the conduit, designed to deliver 25,000,000 gallons a day, was delivering almost 3,000,000 gallons more than the expected amount The pipe company has received, according to contract, a substantial bonus, for the total leakage was found to be only about 83 inch-gallons for the whole line, and the bid price was based upon 165 inch-gallons for the 60 and 150 inch-gallons for the 54-inch pipe.

The pipe was manufactured in 12-foot lengths, in a plant whose capacity was 96 such lengths a day. This plant consisted of four independent units, interconnected with switching tracks. Each unit consisted of cement storage sheds under which were the mixers; the gantry track and the double crane which poured the concrete and handled the forms, the reinforcing, and the finished pipe; the bases on which the pipes were poured; and the racks on which they were cured. Each length was reinforced for a certain head and so had to be distributed to a certain point in the line. The reinforcement consisted of an inner cage of triangular mesh, and an outer cage of mesh or welded steel bars, according to the internal pressures. The pipe was poured between steel forms, very carefully designed and handled so that a remarkably smooth surface resulted. The joint is known as the lead-steel joint, formed by a lead, fibre-filled gasket caulked between the galvanized steel bell-and-spigot rings. After the pipe had been poured, it was covered with canvas jackets and allowed to stand under moist steam for three



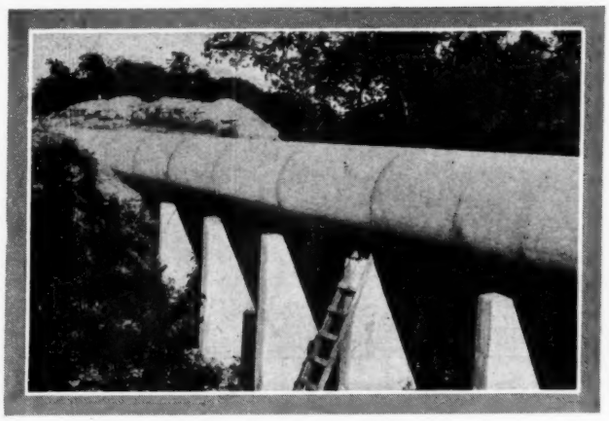
LAYING PIPE IN 25-FOOT TRENCH
Laying crane at left. Gas shovel and dragline used for excavation beyond an Armco culvert used to carry small stream across pipe line.

days, which hastened the process of curing. It was then placed on the racks, where it remained until ready to be loaded onto the cars of the Spavinaw Railroad and to be hauled to its position in the line. Each pipe length weighed approximately seven tons, and it is one of the records of the job that a length was never dropped.

The pipe was distributed along the right of way as fast as the railroad could handle it, but the trench was excavated ahead of laying only a short distance and immediately backfilled. A trench unit usually consisted of two gasoline shovels excavating, a locomotive or caterpillar crane laying, and a dragline backfilling. When operations were at their height, there were five such units working simultaneously along the line. Thirty-five to forty joints of pipe was considered a good day's work for one unit. The center of gravity of each length of pipe was marked on it in the yards, so that when a cable was slipped around the joint at this point, it swung perfectly level over into the ditch. The cranes were each equipped with their own track in two lengths, which they carried along with them, or with crawler tractors, and so left the railroad track free for the passing of pipe trains.

In general, the conduit trench followed the contours without deep cuts or fills. The typical trench section called for 18-inch cover, 84 inches width for the 60-inch pipe and 78 inches for the 54-inch. Unless the trench was wet or in rock, the pipe was laid on the natural material; in the two cases excepted, suitable material was supplied for the bed. After joining the lengths, the pipe was backfilled. Caulking was done from the inside after the backfilling was finished and any slight settlement had taken place. At a later date space between pipes was filled with mortar to make a perfectly smooth interior. Any curve up to 3° was handled by deflections in the flexible joint, but at sharper curves or sudden changes of grade, monolithic concrete jackets, reinforced for the proper stresses, were constructed around the ends of two abutting lengths.

LAYING SIXTY-INCH PIPE IN HADDON'S CUT



CROSSING McNAIR'S CANYON

There were many special laying problems, solved in various ways. At narrow ravines, the pipe was carried across on reinforced concrete beams and piers. Under the five railroads crossed, the pipe was entirely surrounded by pre-cast, reinforced concrete pipe of 84-inch diameter and the space between filled with hydraulically packed sand. In the upper section of the conduit was the heavy rock excavation known as Haddon's Cut, a limestone ledge a mile long through which a 22-foot trench was opened. Portable compressors furnished the air for drilling with jack-hammers. The first ten feet was taken out with gas shovels, and the remainder with a clam shell bucket. For about a half a mile east of the tunnel approach there was some very heavy excavation through soft, shaly formation. Here a trench averaging 25 feet in depth was dug. A dragline stripped the first ten feet of cover to a 40-foot width, and after this was done, gasoline shovels on pads excavated the remainder of the trench to the usual width. Due to the extra width of the trench at the top, no cave-ins were experienced.

Verdigris river, with its high, narrow banks offered a problem. Here an inverted siphon 700 feet long was excavated in tunnel through the rock 35 feet beneath the bed of the river, and the pipe lowered into this on tracks on which a pipe cradle fitted. Pipe, cradle, and track were all grouted solidly into this tunnel.

Grand river, at the upper end of the conduit, is 800 feet wide at the crossing with rock outcroppings in the bed of the stream. Here cofferdams were constructed, eight in number, the railroad bridge piers serving as one side of the cofferdams. A trench was excavated in the rock, the pipe laid from the bridge, and the entire line encased in a concrete jacket. An unusually wet season, with floods that came regularly with the construction of each cofferdam, made this a long and tedious job. The bridge was so constructed that the 30-foot steel spans, ten in number, in the center of the stream, could be taken out. Flood reports were sent down the valley daily, and at news of one approaching locomotive cranes lifted these spans out and carried them to the bank and the flood carried its debris on through the bridge. This was done seven times in the course of the

PIPE IN VERDIGRIS TUNNEL

work. When the last length of pipe was laid on the banks of this river, the conduit was completed and ready for the gates to be lifted at the dam. On November 1, 1924, the water roared into the line at the dam and the second day thereafter arrived at Mohawk.

Among the most jubilant were the members of the non-partisan Water Commission who had given three years of their time and effort to gain a good water supply for their city, and to whose ability and interest the success of the project is largely due. Under their direction, two bond issues, one for $6,800,000 and one for $700,000 had been passed to pay the cost of this project. They had let seventeen contracts to twelve different firms. They had asked Gen. Goethals to recommend to them the source; they had called for a bond issue of $25,000 to make preliminary surveys on which estimates of cost could be based. W. R. Holway of Tulsa was the engineer they secured to make these surveys with J. D. Trammell of Fort Worth, Texas, as consultant; and the same two engineers were retained to prepare the plans and specifications with Dabney H. Maury of Chicago as consulting engineer. Mr. Holway was chief engineer on the construction of the project, and Col. Maury was the consultant.

For years Tulsa had been using the turbid, oily, hard, salty waters of the Arkansas river. She had built an expensive and up-to-date filter plant which could remedy many of the deficiencies of this water but which could not make it palatable or could not soften it without prohibitive expense. There could be no industrial development for a city with such a bad supply. Now she has a soft, palatable water in unlimited quantity.

## Inspector's Duties

Contractors are as human as other people and perhaps as large a proportion of them are likely to endeavor to increase their profits by skimping jobs as is the case in any other line of work conducted by human beings. Consequently the inspector is necessary to insure that public work is carried on without faults of omission or commission. The value of the inspector and how he should perform his duties are well covered by the following, which was published in the December issue of *Concrete Highway Magazine*:

**Some Do's and Don'ts**

Don't carry a chair. A good inspector wears out the knees of his trousers and the soles of his shoes.

Be friendly with everyone on the job; familiar with no one. Familiarity dulls the edge of an inspector's authority.

Be courteous to visitors. Future paving depends upon public good-will. Do not prejudice the public against road improvement by flippant answers to what may seem to be foolish questions.

Orders should be given to foremen, superintendent or contractor only. This rule does not apply to things of minor importance such as the correction of form alignment, elimination of a high or a low spot in the subgrade or other routine matters. In such things it is proper for the inspector to call the defect to the attention of the workmen responsible for that particular part of the job.

Do not waste workmen's time by carrying on a conversation with them.

Be severe at the beginning of the job. An erroneous method is more easily corrected the first time it is practiced than after it has been in use, and the reputation of being slack or "easy," though it is quickly attained, is hard to overcome.

An inspector usually enforces his commands through personality. Be sure your judgment is so cool, fair and impartial and your knowledge of the work so thorough that you command respect and obedience.

Don't argue. Refer disputed questions to your superior and, until you hear from him, use your own best judgment.

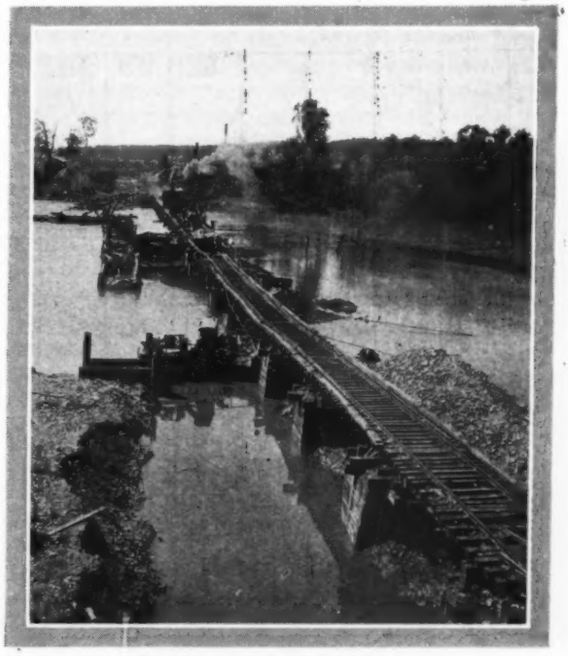
Aid the contractor at every opportunity so long as it does not affect the quality of the pavement adversely.

The first batch of the day is the one most likely to be bad. Be there to see it mixed.

The last work of the day is most likely to be poorly finished. It should be checked before you leave.

Do not try to magnify your own importance by telling outsiders of the errors you have corrected or of the "crooked work" you have uncovered. The quality of the completed pavement will measure your ability and will be your strongest testimonial.

Proper inspection is a man-sized job. It requires constant vigilance, diplomacy and good old-fashioned backbone. Good inspection may add several thousand dollars to the value of the road without adding materially to its cost.



GRAND RIVER CROSSING

# Are Microscopic Animals a Factor in the Foaming of Imhoff Tanks?*

By James B. Lackey†

That the process of sewage purification is largely the work of bacteria has been repeatedly pointed out, and sufficient work has been done to show some of the groups present and the work some of these groups perform. Along with the bacteria there exists a protozoan fauna which is but little known. In the activated sludge process the principal genera have been listed and the numbers per cubic centimeter which have been found in certain plants estimated. Protozoan inhabitants of sprinkling filters have also been listed and counted. Some knowledge of protozoa as indices of pollution is published in scattered works, and finally there are a few speculations as to the probable value of the protozoa in some of these cases.

But in Imhoff tanks and the various kinds of septic tanks, the protozoan population seems to be absolutely neglected. It will probably surprise many sewage workers to find that one exists. But such is the case, and at times this protozoan fauna is present in such numbers that it must undoubtedly exert some sort of influence on the process of purification.

Work at the Sewage Investigations Laboratory at New Brunswick, N. J., had led to a fair knowledge of the kinds and distribution of the protozoa in the tanks. When a tank is functioning well, there are but few protozoa in it—up to 20,000 small flagellates and 2,000 small ciliates per cubic centimeter. If this number seems large, one has but to compare it to the bacterial population of the same tank, as shown by the bacteriologist of the Sewage Substation, and others. However, when a tank foams, the tale is different. At such times the numbers have gone to 250,000 small flagellates, and 20,000 small ciliates per cubic centimeter. This is not an isolated occurrence. Every time a tank has foamed its protozoan population has shown an enormous increase.

Figure 1 shows the history of tank 3 of the plant at Plainfield, N. J., for the period from August, 1923, to December, 1924. In every case of foaming it will be seen that protozoa increase rapidly. It is easily conceivable that a tank could foam without this occurrence, but it has never happened in the case of any foaming tank of which samples were examined in this laboratory.

The protozoa in these tanks belong to a very limited group. Most of them are sapropelic forms, that is, they attack the sewage directly or live on material released in the processes of decomposition, as partially broken down protein material or substances present in dissolved form. Very few of them subsist on the bacteria which are present. Microscopic examination of both living and stained protozoan specimens proves this directly beyond doubt. The bacteria present are popularly supposed to attack and break down the sewage through enzyme action until it is no longer offensive. Too little is known of the physiological activities of the protozoa at present, to conclude that similar work is performed by them. But in the case of the sapropelic forms, no other answer seems probable. However, the probable reason why the study of

*Paper 203 of the Journal Series, New Jersey Agricultural Experiment Stations, Sewage Substation.

†Research Zoologist, Sewage Investigations Laboratory, State of New Jersey.

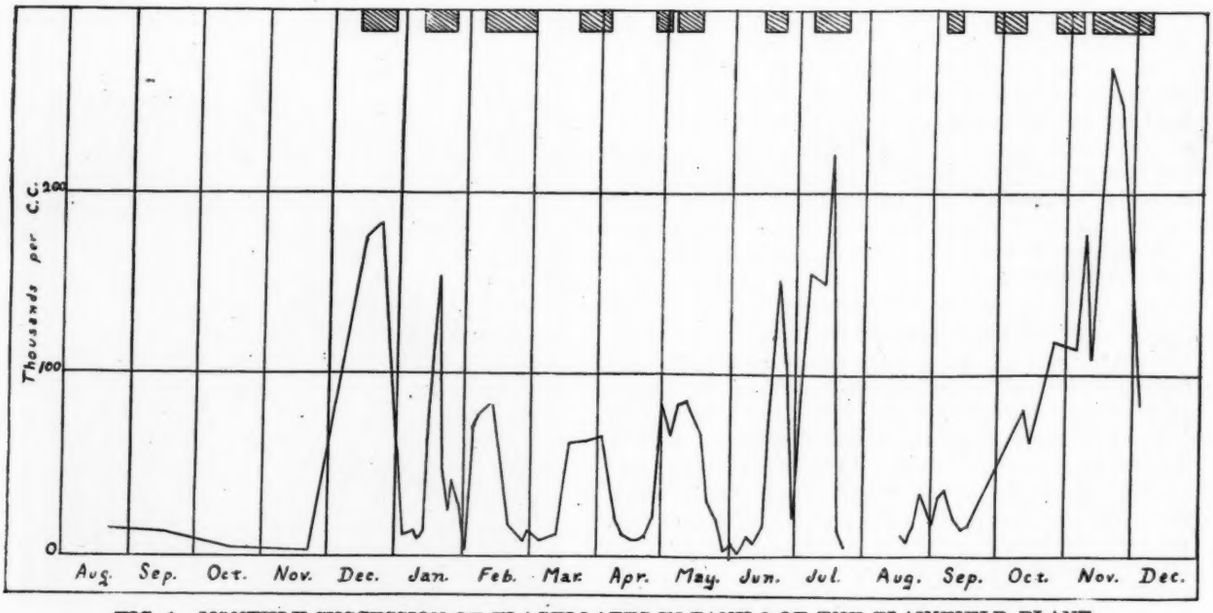



FIG. 1. MONTHLY SUCCESSION OF FLAGELLATES IN TANK 3 OF THE PLAINFIELD PLANT. Shaded areas indicate periods of foaming.

protozoa in sewage disposal has been largely ignored is the same reason why the work of protozoa in soils has been overlooked for years; the numbers present are usually not sufficiently large to make their appearance impressive. In this connection, it is worth noting that some common soil protozoa are likewise common to the Imhoff tank sewage. Among these are a number of bacterial feeders which, in the case of soil, have been discussed to some extent as possible limiting factors in soil fertility (because they destroy beneficial soil bacteria). But these bacterial feeders are not concerned to any appreciable extent in the large increases of tank fauna at time of foaming—it is the sapropelic forms which show the great increases.

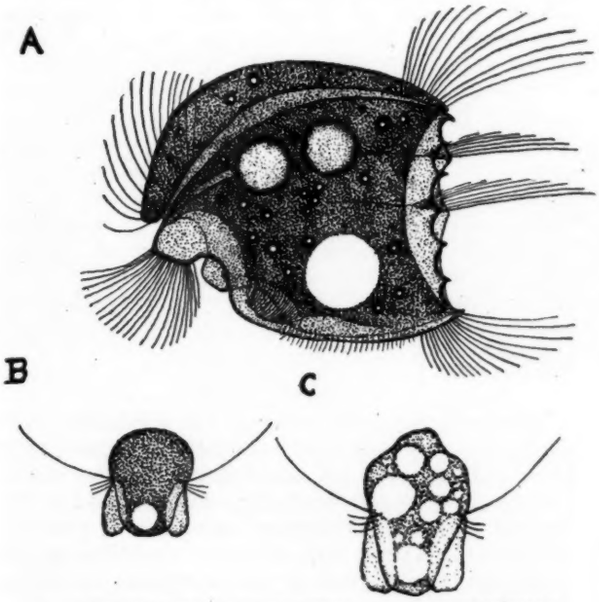
It has now been found by us that the protozoa are sometimes present in large numbers in Imhoff tanks. Since we have shown a potential aid or hindrance is to be expected from them, it is worth while to make a comparison between size and numbers of protozoa and bacteria.

The bacteria in the tanks are of all sizes and shapes. Rod-shaped forms are very abundant, as also are coccus forms which occur in aggregates. Measurements of some rod-shaped ones vary from 3 to 25 microns in length, excepting some more occasional ones which are much larger. In diameter they are from 0.1 to 1 micron. The largest coccus types are rarely over 1 micron in diameter. Trepomonas agilis, the small sapropelic protozoan, which occurs in such great numbers when foaming occurs, is from 10-25 microns long and 8-20 microns wide. Its thickness is from 5-16 microns. If we assume that the dimensions of a bacterium are 20 microns by 1 micron in diameter, its volume would be about 15 cubic microns, and taking 15 microns long by 10 microns wide by 6 microns thick, for the average dimensions of Trepomonas, a rough estimate of its volume is 600 microns or 40 times greater than that of the bacterium. On this assumption, 200,000 Trepomonas in one cubic centimeter would be the equivalent in volume, of 8,000,000 bacteria.

But we have not considered the ciliates. The dimensions of the largest ciliate (Metopus) found in the tanks, are variable but will average 100 microns long by 40 microns wide. Due to certain irregularities in its body form a fair estimation of its volume would be 40,000 cubic microns. The smallest ciliate (Holophrya) has a volume of about 3,000 cubic microns. We will take instead the volume of Saprodinium, another common tank ciliate, which is of an intermediate size between the two. Its shape is quite irregular, but it is 40 microns long, 35 microns wide, and 15 microns thick. A fair estimate of its volume is 12,000 cubic microns. The volume of one of the coccus bacteria whose diameter is 1 micron would be 0.53 cubic microns and thus the volume of 5,000 ciliates in a cubic centimeter would equal that of 114,000,000 coccus bacteria in the same cubic centimeter.

Thus the protozoa in a cubic centimeter are seen to be comparable to 122,000,000 bacteria. In a tank which was foaming, the numbers of bacteria per cubic centimeter have been shown to vary from 4 millions to 300 millions. Thus it is seen that the protozoa may more than equal the bacteria when the volumes of the two are compared. As a matter of fact, these numbers are conservative for the size of the protozoa, and the average number of bacteria seems to be around 100 millions per cubic centimeter. This statement is not intended to be more than a rough comparison, but it is a comparison which will at least have the virtue of meaning something, and it is backed by figures obtained in work on tanks during periods of foaming and on actual microscopic measurements made in the Sewage Investigations Laboratory.

It is not intended at this time to assume that the protozoa are in any way responsible for digestion, as the bacteria are, nor is the assumption intended that the amount of digestion is a function of volume. It is intended to show that the protozoa have some basis of comparison to the bacteria, at certain times. The other questions remain to be investigated. That they should be worked out, in order to get the most efficient and most economical disposal of sewage, is imperative. For they are there; they find a suitable environment, as is evidenced by their rapid reproduction at times, and they are not innocuous, but either as a benefit or a hindrance, they exert a decided influence on the processes going on in the tank.




A—SAPRODINIUM PUTRINUM. B—TREPOMONAS AGILIS. C—ABNORMAL FORM OF TREPOMONAS. ALL FIGURES x 570.

## Street Cleaning in Manchester

Manchester, England, according to the latest annual report of its Cleansing Department, contains 646½ miles of streets requiring continuous cleaning. During the twelve months the department collected 343,405 tons of refuse, the net cost of collection and disposal of which was 308,521 pounds. The department staff consisted of 1,760

employees and it had charge of 33 yards and depots, 38 destructor cells and 27 boilers, 5 private railway sidings, 3,725 acres of land, 588 horse-drawn vehicles, nine motor sweepers, three motor dump wagons, four locomotives, 103 broad gauge railway cars, 254 light railway trucks and 25 miles of light railway, and 13 barges and a steam tug. At one destructor plant, central heating is provided for several hundred houses by incineration of rubbish. Much of the land owned is swampy or wet and is used for dumping refuse.

# Fitchburg Sewage Treatment Plant

**The operation of the Imhoff tanks, trickling filters, secondary tanks and sludge beds, and some new features introduced. Cost of operating plant.**

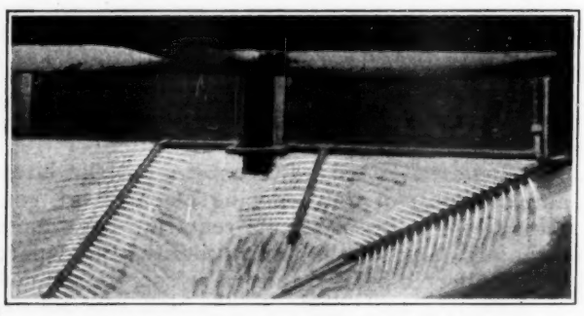
The report concerning the sewage treatment plant of Fitchburg, Mass., made by David A. Hartwell, Commissioner of Public Works, and Herbert B. Allen, chemist in charge, for the year 1923 contains, as usual, a number of interesting features. This plant has been in operation nine years, during which time the population has increased from about 37,500 to 39,000. Owing, probably, to this inconsiderable increase in population, the plant continues to be adequate except that new grit chambers and additional sludge beds are needed.

### IMHOFF TANKS

During the year in question repairs were made in many places to broken-down portions of the curtain walls of the chimneys and to the slopes and sidewalks of the Imhoff tanks. The gradual weakening of the curtain walls was caused partly by the corrosion of the reinforcement metal and resulting weakness against pressure.

In spite of grit chambers, considerable grit reaches the Imhoff tanks and "has at times rested heavily on the slopes leading to the digestion compartments, and the weight of the grit has been the cause at times of the final collapse of portions of these walls."

The heavy solids deposited on the sloping bottoms of the hoppers of the Imhoff tanks do not sludge readily to the suction of the sludge air-lift pipes. A flushing device was installed in the two end hoppers of one tank "for the purpose of maintaining greater uniformity in the density of the sludge and facilitating the removal of heavy solids by means of the air-lift." A 3-inch pipe was installed extending from the top of the tank at each corner leading to a hopper, from which 2-inch branches were led, one line running down the middle of the slope to within 2 feet of the extreme bottom of the hopper and two lines extending down each slope 5 feet 4 inches and 7 feet 6 inches, respectively, from each upper corner of the hopper bottom. Each of these 2-inch pipes is provided with two rows of 3-16-inch holes drilled at a 30-degree angle 6 inches apart, and each arm of the flushing device has a half-inch eccentric nozzle outlet for flushing each valley and sloping bottom of the hopper. There is good water pressure at the plant and the size and number of outlet holes were designed to maintain this at between 60 and 75 pounds. The complete cost of installation for the two hoppers was $669.80. When this tank was in operation, each quarter section of the end hoppers was flushed for two minutes. Marked agitation was observed in the side vents and chimneys but no disturbance was seen in the sedimentation compartment.



FLUSHING DEVICE IN IMHOFF HOPPER.

### TRICKLING FILTER

The trickling filter received the entire flow of settled sewage during the year and was operated at an average rate of 1,710,000 gallons per acre per day, the maximum rate for any 24-hour period being 3,710,000 and the minimum rate 660,000.

"The pipe lines have been flushed and drained four times during the year, which has helped materially in reducing nozzle clogging by growths that develop in the pipe line and are subsequently scoured off.

"The number of nozzles cleaned during the year averaged 16.1 per day, equivalent to 3.8% of the total number of full-size nozzles in use."

"The worm life that is so important a factor has been in evidence at all times during the year. It is, of course, more abundant during the warm weather." The filter flies during the fall were found as far as 500 feet away from the filter. The season life of the filter spider or tick does not seem to be quite so long as that of the fly, which is one reason why the fly is more in evidence in the early spring and fall. During the summer the spider or tick holds the fly in check apparently by destroying its larvae.

### SECONDARY TANKS

The method of disposing of the secondary tank sludge by pumping to the digestion compartment of one of the Imhoff tanks and allowing digestion to take place with the sewage sludge has proved entirely satisfactory after three years of operation. There has been no foaming in the vents of the digestion compartment receiving this sludge.

Whenever the temperature goes below zero

for two or three days in succession it becomes necessary to remove ice from the secondary tanks, where it reaches a thickness of 2 to 4 inches.

SLUDGE DISPOSAL

The sludge drying beds have a total area of 0.42 acre.. They were dosed an average of 8.09 times during the year, receiving the first dose in May. They received an average depth of 10.94 inches of sludge having an average specific gravity of 1.024 and a dry solid content of 8.41%. A total of 1,193.26 cubic yards of air-dried sludge containing 420.61 tons of dry solids was removed from the sludge beds during the year. About 5% of this was hauled away by farmers and the rest was disposed of on a dump a little distance away.

The time required for drying sludge varied from a maximum of 69 days when applied to a depth of 12 inches in the spring to a minimum of 8 days when applied to a depth of 6 inches during the best drying weather. The average time for drying, not including the sludge left on the beds all winter, was 32 days. The cost of cleaning the sludge beds amounted to $663.29, equivalent to 56 cents per cubic yard removed and $1.57 per ton of dry solids. The total cost of sludge bed operation and maintenance, including overhead, was $1,079.49. The total cost of sewage disposal maintenance was $13,661.95, equivalent to $11.80 per million gallons of sewage treated or 35.1 cent per capita served. The force at the sewage disposal works was a foreman, two night watchmen and from one to three laborers, as required.

# Activated Sludge in England

**Three English variations of Activated Sludge treatment discussed at meeting of Managers of Sewage Disposal Works. Rotating air diffusers.**

At the annual meeting of the Association of Managers of Sewage Disposal Works, an English society, in December last, practically all of the discussion was confined to the activated sludge treatment of sewage. Three systems are being promoted in England known as the "diffused air," "simplex" and "bio-aeration." The "diffused air" method is, we understand, that used in Milwaukee and the other earlier activated sludge systems in this country.

The "simplex" system is described by the promoters as follows: "The sewage first enters the aeration areas, where it is circulated from the bottom to the atmosphere through an uptake pipe or tube by means of a vaned cone revolving at the top. By this means sufficient oxygen is absorbed from the air to purify the sewage. When the sewage is purified, the liquid passes into the settling areas, in which the sludge in suspension is settled out. The clear liquid then flows over weirs to the nearest stream or river. The process is adaptable to existing or new works and to rectangular or circular tanks, either deep or shallow and in one or more units . . . All the mechanism, which is simple, is above water-level and easily accessible."

In the "bio-aeration" plant, each unit consists of an aeration or circulating tank, settling tanks and a gauging chamber. Before going to these, the sewage passes through detritus and screen chambers and preliminary continuous-flow settling tanks. In the Sheffield plant the aeration tanks, which were reconstructed from percolating filters, vary slightly in shape and capacity, but are approximately 265 feet long by 130 feet wide by 4 feet 5 inches deep below water level and have an approximate capacity of 900,000 gallons each. The channels are rectangular in section, rounded and connected at the ends and forming a continuous channel in each unit averaging 5540 feet in length. In each unit are 21 paddles operated by four 45-brake-horsepower motors. Each unit is provided with nine settling tanks of the Dortmund type of pyramidal shape, 25 ft. 3 in. x 25 ft. 3 in. x 22 ft. 6 in. deep, with a capacity of 39,000 gallons. The effluent flows into collecting channels and thence to a gauging chamber. The sludge evacuated from the settling tanks passes to sludge wells situated at each end of the pump house, each with a capacity of 30,000 gallons. Thence the desired amount of sludge is pumped to the circulating tanks, while smaller pumps remove the surplus sludge either to lagoons or to the crude sewage channel feeding the preliminary settling tanks. Twelve bio-aeration plants have been adopted by English municipalities and some are already in operation.

At the meeting of the association W. T. Lockett described experiments conducted in collaboration with Dr. Arden at the sewage works of the Manchester Corporation. "An aerating apparatus was devised to study the effect of the application of a continuous supply of air admitted in volumes substantially less than those required for the adequate mixture and circulation of the mixed liquor in apparatus having a high ratio of diffuser to tank area, such as that used previously." This "consisted essentially of one or more radially extending arms provided with a porous covering—e.g., porous tile—arranged in plan to the shape of a sector of a circle, and adapted to rotate about a pivotal center near the bottom of the tank. Air was introduced through a central vertical tube and passed beneath and finally through the porous covering into the sewage. The rate of rotation of the arms and of the air supply could be varied as required. . . . The results obtained . . . were similar to those obtained previously with an intermittent air supply.

It was stated that regular observations over a period of two years have established the fact that, under conditions existing at the Withington works at Manchester, the maintenance of a small quantity of dissolved oxygen in the mixed liquor for at least some portion of each 24 hours secures a sludge of full activity; while if the dissolved oxygen present exceeds a given amount, the flow to the plant may be increased until the dissolved oxygen content of the final effluent is reduced to what has been established previously to be the economic point. For

control purposes the effluent is sampled every three or six hours. Samples taken at noon and at 3 P. M. were found to contain the greatest quantities of dissolved oxygen.

The results so far obtained in practice with the ridge and furrow system at the Withington works have led to the following conclusions: With a diffuser ratio of 1:7 and a tank 6 feet deep with 60,000 gallons capacity, an air supply of less than approximately 8.5 cubic feet per square foot her hour, including tne air required for air lift operation, or 7.2 cubic feet per square foot per hour actually passing through the diffusers, is not economic. This volume of air would, therefore, appear to be that most effective for applying to a mixture of sludge and sewage in such aeration tanks. Application of air at this rate throughout the 24 hours for three years continuous operation has given satisfactory results. No bulking of sludge has occurred during this period. By maintaining control of the plant by determinations of the dissolved oxygen content of the final effluent, it has been possible to increase the effective capacity of the plant approximately 50% and reduce the air consumption from 1.4 cubic feet of free air per gallon of sewage (British gallon) to 1.1 cubic feet. For the twelve months ending March 26, 1924, the average air consumption at this plant was 1.08 cubic feet per gallon. An air pressure of not more than 3½ pounds per square inch is required and the power required was not more than 21 brake-horsepower per million gallons of sewage treated. The sewage treated in this plant was domestic sewage below average strength.

Mr. Lockett stated that laboratory experiments indicated that a variable intermittent air supply with or without an alternative continuous supply would give flexibility or elasticity to the purification process in addition to economy in air consumption; and that similar results could be produced by an air distributing apparatus such as that described above. Apparently the only conclusion that he drew from practical experience was that a tank of the ridge and furrow type operated on the principle of a continuous supply was a very efficient and economic system giving eminently satisfactory effluents at reasonable cost. Storm water, he stated, can be dealt with at rates equal to three times the dry weather flow.

## Refuse Salvaging at Birmingham

A new plant, to cost nearly half a million dollars, is to be installed to handle the refuse from 150,000 of the population of Birmingham, England, which is estimated to amount to 36,000 tons per annum.

The refuse will be collected by electric vehicles, of which thirteen are ready for service. These will dump refuse into steel hoppers, each of 10-tons capacity and fitted with a device for feeding the refuse at a uniform rate to circular screens.

The purpose of these screens is to remove the dust, estimated at 40% of the whole, which will either be dumped or sold for fertilizer. The dust will be conveyed by a column of moving air to cyclone separators, from which the dust will fall into the barges by which it will be removed.

All iron or steel materials will be removed from the refuse on the screens by magnets and the remainder will be discharged onto belt conveyors, from which the saleable material will be sorted out. The balance of the refuse will be delivered into storage hoppers, from which it will be charged into a destructor of the Heenan type, of which there are two units of 4 cells each, each unit being estimated capable of burning 40 to 50 tons of refuse in 24 hours. The heat from the destructor will be used to generate steam. The clinker will be crushed, passed through a magnetic separator, graded by screens and stored in hoppers, from which it can be drawn for use.

Just before the belt conveyor discharges the tailings into the hoppers, the material passes in front of a suction plant which removes waste paper and transfers it to a grading separator which delivers the paper, free of dust, to a baling press.

# Imhoff Tank Discussion

**Experiences with foaming and attempts to correct it at Emporia, Newton, Enid and Whittier. Comments by Dr. Imhoff.**

In "PUBLIC WORKS" for March, April and May we gave abstracts of an exhaustive paper on Imhoff tank construction and operation by Harrison P. Eddy and discussions of the paper by several engineers. Later discussions have been contributed by letter by several engineers, and we abstract below some of the more interesting features from those by A. P. Learned, assistant engineer with Black & Veatch, and Dr. Karl Imhoff.

Mr. Learned gave information concerning four Imhoff tank installations that he had visited a few weeks before, those at Emporia and Newton, Kans.; Enid, Okla., and Whittier, Calif. Important features of his discussion were the descriptions of mechanical sludge agitators installed at Enid and at Newton.

The Enid tank, built in 1921, is 54 feet long and has three vent chambers running its entire length. Across the top of the tank are four tie beams which thus divide the openings of each vent chamber into five compartments, or fifteen compartments altogether. In 1922 this tank began to foam, and the officials in charge of operation constructed a mechanical agitating device which has operated so satisfactorily that there has been no further foaming.

Fifteen of these devices were constructed, one for each of the vent chamber openings. Each agitator consisted of a 1-inch galvanized iron pipe used as a horizontal shaft, 6 inches shorter than the opening between beams. About one-quarter of the length in from each end was inserted an ordinary cross holding two nipples, one 4 inches long and the other 2½ inches, and a cross was screwed on the end of each nipple. Into each end of each cross was screwed a piece of pipe approximately one-quarter the length of opening between beams, set parallel to the horizontal shaft; each pair of pipes thus forming a paddle, four paddles to a set. The two crosses on the shaft were set at right angles to each other to

make the paddles balance each other. This was set with the shaft just at the normal water-level of the tank. The shaft and paddles are revolved from a main shaft by means of sprocket wheels and a chain drive. The paddles are revolved at a speed of 4½ revolutions a minute.

The operator uses this agitator one-half hour in the morning when he first comes to the plant, fifteen minutes at noon and fifteen minutes just before he leaves at night. At the time of each treatment he skims off such small amount of matter as is not easily settled or digested, consisting of seeds, vegetable leaves, strings, match sticks, etc. It is reported that this agitator has not only prevented foaming, but that there is less odor at the sprinkling filter, probably because the continuous free escape of gas reduces the concentration and perhaps the formation of stronger gases. It requires between 2 and 3 horsepower to start the battery of agitators, but less than 1 horsepower to keep them going. The cost for power averages from 10c. to 13c. a day. The materials cost $350, exclusive of the motor and the speed reduction set.

The Newton agitator is of an entirely different design, but is said to be satisfactory. This tank has only one scum compartment which is 28 feet long and 2 feet wide. A light walking beam was built up of 1-inch angles and supported longitudinally over the center of the scum compartment. From this beam are suspended four mill screws spaced at approximately equal intervals along the length of the chamber. The walking beam is operated to such an angle that the agitators travel between 12 and 18 inches vertically. The mill screws extend about 4 feet into the water. The walking beam is connected to the shaft of a vertical motor that drives one of the sewage pumps with reduction gear that gives it between 4 and 4½ oscillations per minute. The writer noted some scum in the vent chamber between the mill screws, but it was not more than 2 inches thick. When this device was first installed the vent was foaming badly and the sludge compartment was well filled. Since it has been in use no foaming has occurred.

Dr. Imhoff touched upon several features of Mr. Eddy's paper, including effect of temperature, preparatory treatment of the sewage, tank design and operation. He agreed with Mr. Eddy that the operation of the tank as measured by gas production increased with the temperature, and stated his belief that when the temperature of the sewage in the tank fell below 45 degrees, the operation would cease to be as satisfactory as otherwise. For this reason Imhoff tanks in southern climates should prove more satisfactory than in the northern part of the United States.

Concerning preparatory treatment of sewage, Dr. Imhoff said: "The application of fine screens for preparatory treatment in two-story plants is not clear to the writer from a technical point of view. In Germany fine screens of good quality are calculated at nearly the same yearly cost (interest, sinking fund and running expenses) as a complete installation of two-story tanks. The addition of fine screens means the doubling of the yearly expenses without improving the results. The collection and removal of the screenings also is an offensive operation. Thus the best advantage of a two-story plant has been lost; namely, having sludge that is without odor and at the same time harmless from a sanitary point of view. If, therefore, fine screens are to be arranged in front of two-story tanks, they should be used only for breaking up the scum before it is introduced in sewage."

Concerning the area of gas vents, he says that, since the early days of the Imhoff tank when both American and German engineers believed that the digestion chamber should be arranged with a very large surface, it has been proved that those having the smallest gas vents shows the greatest security against floating and foaming sludge. Therefore, that, although the settling tank should have as large a surface as possible and as small a depth, the digestion chamber should be built as deep as possible and with no surface at all. In new German plants the digestion chamber is completely closed on top by a wooden cover, thus keeping the floating sludge entirely under water and allowing only the gas to escape, which it does through the cracks in the tongue-and-groove joints used in making the cover. The cover is protected from the sludge by a layer of gas which always exists between them. On the side of the tank below the level of the wooden cover is an opening controlled by a gate which is used to draw off the floating sludge in the same manner as the bottom sludge.

Dr. Imhoff gives instructions for operating a plant that is overloaded. He states that the engineers of the Ruhr-Emscher district have had a great deal of experience along this line and that the following are the results of such experience:

"1. Draw off the sludge frequently, in order to make good use of the digestion chambers.

"2. Enlarge the sludge drying beds, in order to dry even sludge of bad quality.

"3. Arrange sludge lagoons for the winter, as is the practice at some American plants.

"4. Construct secondary digestion chambers, in which the sludge, pumped from the two-story plants, may be stored for some time before it is placed on the sludge drying beds. Such tanks are built in England (Birmingham) with earth embankments."

## Fire-proof Streets in Astoria

The business section of Astoria, Oregon, was wiped out by a fire on December 8th, 1922, the destruction including the pavements, which had been built as creosoted timber viaducts with plank floors. This construction had resulted from the raising of the city several feet above the original grade in order to allow the use of basements, the business section of the city being really built on tidal flats.

In rebuilding the city and the streets, a method of construction was employed that probably has not been used elsewhere.

A row of piles was driven under the curb line and another line about 5 feet outside of this, each line being capped with a concrete beam a foot or two below the original ground level. On the line of piles immediately under the curb, a vertical wall was built 12 in. thick up to an elevation 4 ft. 6 in. below the sidewalk level, from which point a 7-in. wall

was continued upward, the top of it serving as the curb. Another vertical wall 8 in. thick was built on top of the other row of piles and carried up to a point 4 ft. 6 in. below sidewalk level, where it was connected with the first wall by means of an 8-in. horizontal roof. This construction was called a "step wall." The roadway space between these two walls was filled with sand dredged hydraulically from the Columbia river.

This step wall construction was calculated to be more economical of materials than the ordinary gravity, cantilever or counterfort wall, and possesses the additional advantage that it provides conduit tunnels in which can be laid dual systems of water, sewer, gas, electric light, telephones and telegraph lines. This conduit tunnel is in general 4 ft. wide in the clear and averages 5½ ft. high. The wall which forms the curb varies in total height from 8½ ft. to 21 ft. but is mainly 12 ft. high.

After the sand fill had settled, it was covered with a 7-in. cement concrete pavement mixed 1-2-3; the pavements varying from 34 ft. to 44 ft. between curbs. The work of replacing with concrete the burned timber construction, which has now been completed, included approximately 27,000 square yards of concrete pavements. Transverse joints with ¾ in. dowels 4 ft. long and spaced 2 ft. on centers were placed every 30 to 50 feet. The sidewalks vary in width from 8 to 13 feet and are constructed of reinforced concrete slabs 5 in. to 8 in. thick supported on 8 in. x 18 in. concrete beams reinforced with three ¾ in. deformed bars; these beams being supported at the outer end by the step wall, and at the inner by 8 in. x 8 in. reinforced concrete posts at the property line.

## Concreting Sewer With Belt Conveyor

The city of Buffalo, N. Y., is now building a storm sewer 7,800 feet long with inside width varying from 24 feet 6 inches to 33 feet 6 inches. The roof is a semi-elliptical arch with a rise of 7 feet resting upon 7-foot retaining walls. The concrete is reinforced throughout using ⅝-inch steel rods.

The concrete is given about a 1:5 mix, the aggregate being bank-run of Niagara River sand and gravel. The concrete is mixed in a central mixing plant installed midway of the job, convenient to railroad sidings and a water supply. The gravel is dumped from railroad cars behind the mixing plant and is lifted to the storage hoppers by means of an endless belt conveyor, and the cement is brought in from the side by a similar conveyor.

The concrete is delivered from the mixer to trucks to be delivered along the line of the work.

The sewer takes the place of and will carry the flow of a creek, and the banks of this stream are so steep and occupied by so many buildings that access to the sewer is practicable only at intervals. To distribute the concrete wherever needed along the sewer, several hoppers and belt conveyors have been located near the bank of the stream. The concrete is dumped by truck into a hopper, which delivers onto a belt conveyor, which carries the concrete to the line of the work, where it discharges it into another small hopper, which, in turn, drops it onto another belt conveyor running parallel to the sewer. This conveyor is 300 feet long and can be moved from point to point along the sewer. It and the smaller conveyor on the bank are operated by a 10-horsepower gasoline engine. When 600 feet of sewer (300 feet each way) have been poured from one position of the hopper and short belt on the bank of the stream, both these are moved about 600 feet down the sewer and the process repeated.

It is found that it takes an average of 6 minutes from the time the concrete is released from the mixer to its discharge into the sewer at the extreme end of the longitudinal belt conveyor.

As this sewer occupies the stream bed, it was necessary to carry the flow of the creek during construction. The normal flow is only from 5 to 20 cubic feet per second, and carrying this through the work did not seriously interfere with it during dry weather. During stormy periods the concrete work has been discontinued.

The sewer rests on rock throughout. After removal of the larger rock, all small loose rock and dirt was cleaned from the sides and the seams with a hose, so that the concrete obtains a firm bond on the rock. The general contractor for the work is Frank L. Cohen, Inc., of Buffalo.

# Rejuvenating Brick Sewers

**Strengthening old brick sewers by lining with reinforced concrete. Concrete dropped through pipes driven vertically from surface to sewer.**

Brick storm water sewers in Greene and Lewis avenues, Brooklyn, N. Y., that were built many years ago at a depth of 30 feet below the surface were found recently to have developed serious cracks and settlements in their arched roofs and several remedies were considered. The cost of reconstructing these sewers by either open cut or tunnel would be very great, and it was decided to strengthen the existing sewers by lining them with concrete. This work, which is now being done expeditiously and economically, strengthens the sewers without materially disturbing the old brick work or interrupting the service of the sewers. The lining that is being constructed is strong enough to resist all the roof stresses and prevent any further displacement of the brick.

The sewer in Greene avenue is a circular sewer 10 feet inside diameter. About 2,400 feet of this is being repaired by placing a lining of reinforced-concrete, which, however, extends only a short distance below the springing line of the arch, since the old invert is still in excellent condition.

A temporary floor platform about 7 feet wide was first built just below the level of the springing line of the arch, and on this was laid the construction track. This floor also served to support the arch forms. Using pneumatic chipping hammers, recesses are cut at intervals into the brick walls a little below the springing line, being carried to a maximum depth of a few inches, to serve as bearings for the concrete lining. About 1,300 yards of broken brick is being removed this way. It is loaded into cars which are run on the construction track to the foot of the shaft and there dumped into buckets and hoisted by a small derrick operated by a Ligerwood engine installed on the street surface.. The roof is shored from the platform in advance of the cutting of these recesses.

Concrete mixed 1:2:4 is used in the lining and is dropped into the sewer through 8-inch pipes carried down vertically from the surface through the arch of the sewer. The concrete so introduced drops into ½-yard dump cars which travel on the 24-inch gauge tracks laid upon the platform. In these cars it is carried to and deposited in the forms in the ordinary way up to the springing line of the arch. Above this point it is discharged behind the forms pneumatically, long and narrow Ransome horizontal-type pneumatic placing machine stationed alongside the track being used for the purpose. As there is not sufficient head room to permit running the cars up a ramp and dumping direct into this, the concrete is shovelled into the barrel of the machine. About one-quarter of a cubic yard is so introduced, the air-tight door is closed, pressure admitted, an electrically driven helicoidal conveyer in the barrel of the machine is operated and the charge is delivered through 25 feet of 6-inch discharge hose. This hose is carried from the machine through an opening left in the top of the wooden end bulkhead and extended along the top of the arch form to within a short distance of the concrete arch already formed. In this way the concrete already in place receives the impact of the wet concrete and the latter then falls down and fills the forms on both sides from the bottom up. The arch is built in 14-foot sections, a section being built with between 60 and 70 "shots" of concrete in about three hours. Part of the concrete in this sewer has been placed by hand and part by machine, and it is calculated that the latter permits a saving of about 30 per cent of the labor and 50 per cent of the time. The machine was installed under the direction of John P. Fitzgerald, a specialist in pneumatic concrete plants, for Booth & Flynn, the contractor for both of the sewers.

When there is much rain, the 10-foot sewer carries a considerable amount of water. Owing to the manner in which the work is performed, this is carried without any damage to the concrete, but the pneumatic machine is removed to avoid injury to the electric motor which operates it.

The Lewis avenue sewer is an egg-shaped one of brick, 4 feet 6 inches by 5 feet 9 inches in inside dimensions. Of this sewer, 2,150 feet is being completely lined with concrete from 6 inches to 9 inches thick, leaving a free area of 4 feet 6 inches by 3 feet. This is about half the capacity of the original sewer, but is said to be adequate for the purpose it is to serve.

The method described above of introducing the concrete into the sewer through vertical 8-inch pipes and of distributing it by cars running on a 2-foot gauge track is being employed. Here the invert concreting is closely followed by arch concreting, both being done in 14-foot sections, using special steel forms designed by the contractor. The invert form is stiffened at the bottom by means of a continuous I-beam and is adjustable at the sides by use of transverse tie rods connecting the top edges and provided with turn buckles. The arch form is bolted to the invert form at the longitudinal joints along the springing lines and has removable crown sections which are set in place in successive short lengths as the concrete progresses, the opening being utilized for introducing the concrete. Before placing the concrete on the invert, care is taken to clean from it all mud that has been deposited by storm water.

The work on both sewers is being performed by Booth & Flynn as contractors, under the direction of A. J. Griffin, chief engineer of the Bureau of Sewers.

## Champaign-Urbana Sewage Disposal Plant Dedicated

An unusual event occurred on November 21st, the formal dedication of a sewage disposal plant —that of the Urbana and Champaign, Ill., Sanitary District. Addresses were delivered by J. D. Dodds, vice-president of the district, Samuel A. Greeley, Prof. A. N. Talbot, Dr. Edward Bartow, David Kinley, president of the University of Illinois, and P. W. Wright, president of the

GREENE AVENUE SEWER BEING LINED WITH CONCRETE.
In foreground, old brick arch, and concrete lining up to springing line. Track laid on construction platform.

district. A tablet was unveiled which gave credit to Professors Talbot and Bartow for their contributions in advancing the science and art of sewage treatment. The exercises were attended by representatives of various women's clubs, the County Medical Association, the Rotary and Kiwanis Club, the Association of Commerce and other organizations.

# Brick Pavement Improvements

**Consideration of fundamental principles of design and construction in view of recent research data and past experience. Subgrade and foundation. Thinner brick surface recommended.**

A paper was read before the 1925 Road Congress by Willis D. P. Warren of the firm of Holbrook, Warren & Van Praag of Decatur, Ill., entitled, "Brick Pavements; Improvements and Modifications of Design." An abstract of this paper is given below.

Of fundamental importance in the development of an economical design of brick pavement are: 1—Recent research data; 2—Differences in design of highway and street pavements; 3—Economy of subgrade treatment; 4—Relation of subgrade and foundation; 5—Thin brick wearing surface; and, 6—Resurfacing with thin brick.

1—Research data are vitally important in the development of an economical brick pavement design, but their greatest value is realized only when considered carefully with full allowance for construction in the past. For example: Referring to the brick pavement tested on the Bates road known as Number 2, this consisted of 4 inches of brick with bituminous filler and a 2-inch sand cushion on a 4-inch macadam base. This section had no marginal curbing, thickened edges, gravel shoulders or any other proper side support to prevent lateral displacement. Years of practical highway construction had already demonstrated that such a section with proper side support provides a pavement of far greater strength than was developed by this test section. While recognizing the importance of research data in developing modifications and improvements, it is essential to bear in mind that the characteristics of existing brick pavements of known strength and merit are the surest guide to economy in design and should not be ignored.

2—There are fundamental differences in design between highway and street pavements, and only by careful analysis of the peculiar local conditions and requirements can true economy in design be accomplished. The drainage conditions are not the same, nor the widths, nor the distribution of the weight of traffic; while the subgrade conditions differ both before and after construction. It may be assumed that there will be few if any excavations in the subgrade of a highway pavement, but in a city pavement such excavations may cover 5 to 15% of the area.

The edge of a highway pavement should be designed to support and distribute the weight of traffic under conditions far more severe than those imposed upon the outside edge of a street pavement. One reason for this is that the subgrade under the edge of a highway pavement is far more likely to be highly saturated with moisture at certain seasons of the year than is the case of the street pavement, in which condition the highway subgrade may easily be displaced laterally. This displacement in a city pavement, even if it tended to occur, would be resisted by the curb which extends above and below the pavement. In his report on the brick roads of Florida, C. A. Hogentogler stated that "inadequate side support was the cause of major defects"; and this fact was very clearly demonstrated on the Bates road.

3—The degree of stability of the subgrade affects not only the foundation, but also the brick pavement as a whole, and accordingly subgrade treatment is one of the most important considerations. It may be safely stated that the greatest field for economy in highway construction lies in the development of a subgrade which will maintain its maximum stability throughout all seasons of the year. Well drained subgrades make possible economical construction of artificial foundations and permit a choice of foundations from a greater variety of materials.

From tests made by the U. S. Bureau of Public Roads it would seem to be possible to create over a bad subgrade a layer which has high bearing value, low moisture absorption, and low volumetric change, by mixing and harrowing into the soil lime, Portland cement, or sand, or by the use of a porous granular layer. Under just what conditions this treatment is economical is yet to be demonstrated.

4—The nature, character and thickness of the foundation of a brick pavement should properly depend upon the stability of the subgrade; and this is secured by reducing the percentage of moisture and is maintained by preventing the free passage of water and capillary moisture from the road shoulders to the subgrade. The prevention of lateral displacement of subgrade materials, and at times of foundation materials, requires the foundation to be thickened under the slab edges and also that the subgrade material be positively confined by the construction of impervious cutoff walls under the slab edges. Local subgrade conditions, prices, and character of traffic should properly govern the design of the foundation and the use of cutoff walls or reinforcement or both. In general, flexibility in the foundation permits of the best development of the supporting power of the subgrade.

Recent investigations have established the point that the per-cent of capillary moisture can be very substantially reduced by increasing the difference in elevation between the highway subgrade and the side ditches or tile drains. In

other words, deeper ditches or drains is one solution of the moisture problem. Reduction rather than elimination of capillary moisture is to be aimed at, as it is the per-cent rather than the presence of moisture which determines the stability of the subgrade.

Taking into consideration the cost of obtaining materials for mixing with the subgrade as mentioned above, together with the cost of removing the additional earth over the entire area of the roadway, it is probable that it will be less expensive to deepen the side ditches; however, the local conditions and prices will determine which method is the more economical.

In addition to the admixture method and the lowering of the water table, a third method is suggested—that of constructing impervious cut-off walls along the sides of the pavement slab. These walls should extend to a depth about equal to that of the side drains, ordinarily about 2 feet below the bottom of the marginal curbing, and should be 3 or 4 inches thick. Where composed of very lean mixtures of concrete, or of bituminous mixtures such as one part Tarvia B or cut-back asphalt to 10 parts of sand, they can be built at a cost somewhat below the cost of 1 inch of additional concrete in the concrete foundation. These walls will prevent the free passage of surface water and capillary moisture from the road shoulders to the subgrade above the horizontal plane of the side drains, which drains will reduce any capillary moisture already existing in the subgrade. As the shoulders along the highway pavement are more or less pervious, the subgrade under the edge of the pavement is subject to saturation even with fairly good side ditches, unless this saturation is prevented by some positive obstruction to the free passage of this water from shoulder to subgrade.

Where treacherous subgrade conditions cannot otherwise be properly remedied, a reinforced concrete foundation will in general prove more economical than a plain concrete in that it will possess a degree of flexibility sufficient to best permit the fullest development of the supporting power of the subgrade, and in addition can be so constructed with the necessary marginal curbing as to provide the maximum side support and the minimum lateral displacement of the subgrade. Flexibility is a very desirable quality in a brick pavement foundation.

The different conditions found under street pavements, and particularly trench excavations, generally make a reinforced concrete foundation the most economical one for such. The reinforcement should be placed near the bottom of the slab. Where reinforcement is desirable, it will, when used in the proper amount, permit a reduction of several inches in the thickness of the foundation. Experiments by Prof. James I. Tucker of the University of Oklahoma, indicate that where a 6-inch concrete foundation proportioned 1:3:5 would be required over a treacherous subgrade, equal strength and more positive construction can be secured by the use of a 3- or 4-inch concrete foundation reinforced with steel mesh fabric or bars weighing approximately 4 or 5 pounds per square yard of pavement and placed about 1 inch from the bottom of the concrete slab.

True economy in the construction of a pavement requires that the investment in the treatment and improvement of the subgrade be more than offset by the saving thus effected in the cost of the foundation.

5—The adoption of a standard size and type of paving brick having a depth of 2½ inches is justified by the demonstrated toughness and durability of brick of this particular depth where used in existing brick pavements. Such brick may properly be used on all except the heaviest traffic streets, and a 3-inch brick is sufficient for such streets. The author suggests the adoption of the vertical fibre, lugless type of brick as a standard.

In considering details of construction, the author says that the best results will be secured by requiring the foundation to be floated, if of concrete, and by spreading a sand cushion to a uniform depth of not to exceed 1 inch. Also, experience and recent tests confirm the wisdom of the present-day practice of using asphalt filler.

6—The use of 2½-inch brick in resurfacing work offers a big field for economy in the maintenance and reconstruction of pavements of various types which have reached or passed their economic life. For resurfacing old pavements of any kind, thin paving brick is found to be readily adaptable in that it can be laid with minimum inconvenience to traffic, is very durable, reasonable in cost, and can be laid with a minimum change of existing grades.

For levelling off depressions in an old pavement so as to secure a uniform thickness of cushion, concrete may be used, or a mastic composition of one part Tarvia B or cutback asphalt to ten parts of sand; which levelling up should cost approximately 20c per inch of depth per square yard of pavement. He considers that the cost and flexibility of the mastic filler make it a very desirable material for this purpose.

"Considering the inherent qualities of toughness and durability, as evidenced in the individual paving brick, and its general adaptability as one of the component parts of an economical type of pavement, it is entirely reasonable to assume that there is a constantly widening field for its use, provided the brick pavement structure as a whole is properly designed."

## Traffic Light Colors

After an investigation of the visibility of traffic light signals (especially by day, when the visibility is poorest), the Bureau of Standards has reached the conclusion that red signal lights are more easily distinguished than other colors, with green second and blue third; a yellow green being considered preferable to the blue green used by railroads. On the average, at a distance of 600 feet a red light could be identified when a 75-candlepower lamp was used, while a

green light required 250-candlepower, a yellow light 750-candlepower and a blue light 1,000. At 1,250 feet the candlepower required was 1,500, 2,500, 3,000 and 7,500 respectively.

## Road Work in Arkansas

The state of Arkansas during 1924 spent $8,900,000 on its highways, approximately 5,000 men having been employed. The work done included 1,150 miles of grading, 415 miles of gravel, 15 miles of plain macadam, 15 miles of asphalt-macadam, 51 miles of asphalt-concrete and 50 miles of cement-concrete. The Highway Department estimates that during 1925 about 2,160 miles of road will be improved at a cost of between $7,000,000 and $8,000,000.

# Combined Haulage in Road Work

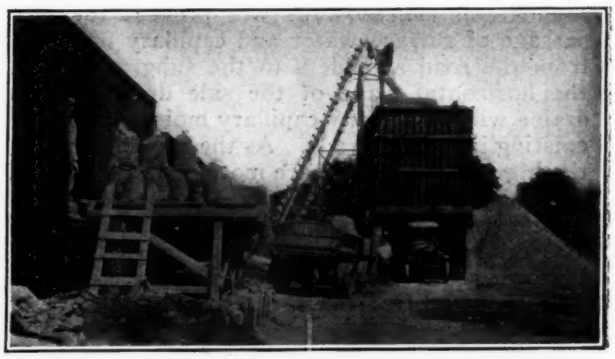
**Batch boxes hauled by truck, transferred to cars, and by them to mixer on an Ohio road job.**

Hauling materials by a combination of motor trucks and narrow gauge railway equipment in constructing a concrete pavement for the Ohio State Highway Department is said by the Mellert & Weidener Company of Medina, Ohio, the contractor, to have been its saving during a very wet period last June and July. During this time there was an unusually great amount of rain and contractors relying on truck haulage were able to operate only about half the time.

The contract consisted of 2.4 miles of 16-foot concrete road. The bins and yard were about 1 mile from the beginning of the job, and this was the minimum length of truck haul while the maximum length of truck haul was about 2 miles. During the short haul three 5-ton trucks were used and at the maximum length of haul five trucks were used.

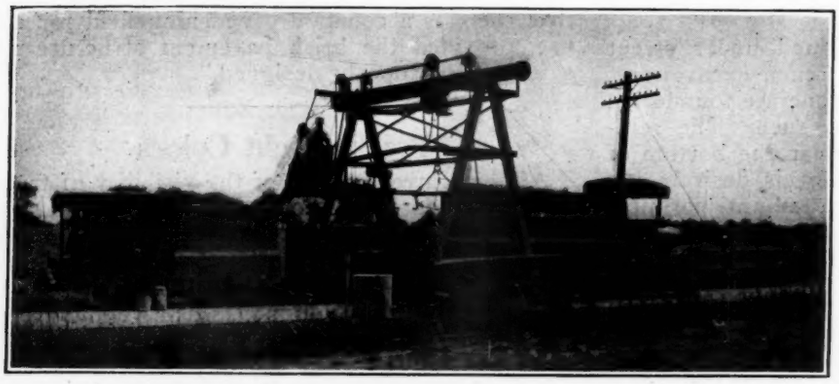
In building this road the first 1½ miles was laid from industrial track, this being the total length of track used by the contractor on this job. Before this mile and a half had been completed the concrete first laid had been cured for the required 21 days and trucks were allowed to travel over it. Accordingly, the track alongside the cured road was then moved ahead and also, of course, the transfer point established for transferring the batch boxes from truck to cars. Each day the transfer point was moved ahead about 500 feet and that length of track removed and carried ahead, this being the average length of pavement laid per day. When the transfer point had been moved to within a mile and a half of the further end of the job, it remained stationary until the contract was completed. This equipment kept the mixer supplied at the rate of forty batches per hour.

Each truck carried four steel batch boxes with watertight cement compartments which were loaded at the material yard, the stone and sand from bins and the cement from cars. The stone bin had a capacity of five cars and was filled by means of a Columbus unloader. The sand bin had a capacity of one-half car and was filled by means of a Galion unloader. The four batch boxes on a truck were filled in five minutes. The force at the material yard comprised five men handling cement and four men handling stone and sand.

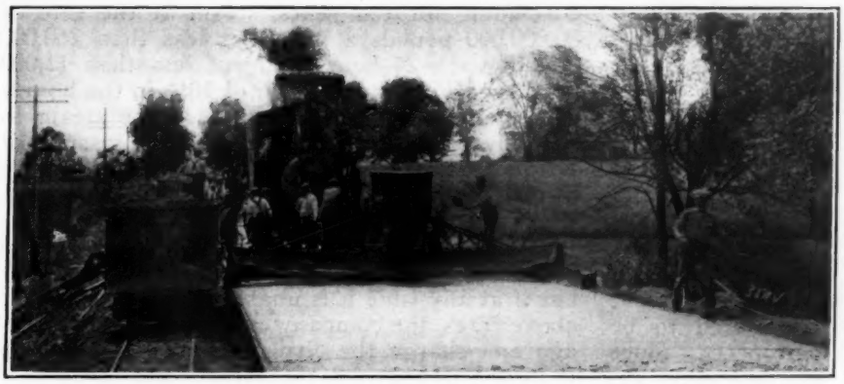


STONE AND SAND BINS AND CEMENT PLATFORM.

The equipment used for transferring the batch boxes from truck to car was built by the contractors. A steel I-beam was supported by two wooden A-frames, one on each side of the road. From this was suspended a Yale & Towne hoist operated by a Ford engine mounted on a platform on one side. Levers fastened to the three operating pedals of the Ford formed the controls. When this transfer equipment was to be moved ahead, a truck was backed underneath it, the transfer raised and a 6x6 slipped under it and across the bed of the truck, when the whole machine could be moved readily. The apparatus complete cost about $1,000. Transfer of four batch boxes from



TRANSFERRING BATCH BOXES FROM MOTOR TRUCK TO NARROW GAUGE CARS.



DELIVERING BATCH BOXES BY RAIL TO MIXER.

a truck to two cars required five minutes, five men being employed, one to operate the transfer, two on the transfer bail and two placing boxes on the cars and shifting cars.

On the first half of the job one locomotive hauling seven cars with two batch boxes on each car easily kept the mixer going with forty batches per hour; but on the last half, which contained a 5½% grade, two locomotives were used. Each train was then made up of six cars with a locomotive in the middle. When the grade was reached the rear three cars were left at the bottom and the three front cars pushed up the hill and left there and the locomotive returned for those at the bottom, carried these up and again coupled up to the first three and continued to the mixer. Two locomotives and four trains of six cars each were used, the locomotives changing from loaded to empty trains at the mixer and from empty to loaded at the transfer point. The industrial track and cars as well as the batch boxes were furnished by the Lakewood Engineering Company, and Plymouth locomotives were used.

It took four men from two to three hours to take up and relay 500 feet of track each day. The track sections were loaded on to a car and hauled by locomotive to the far end. The contractor calculated that it cost about $150 per mile to lay and take up the track, this including the switches, one at the transfer point, another at the mixer, and one passing siding between these two points. One man was detailed continually on track maintenance. Four men were required to handle batch boxes from the car to skip at the mixer and to shift the cars. The mixer was operated by an operator and a fireman, and five men did all the work behind the mixer, three spreading the concrete and placing the circumferential reinforcement, one operating a Lakewood finisher and the fifth acting as his helper. Using a Lakewood subgrader, seven men with a foreman were able to keep the subgrade ahead of the paver and set all forms.

## City Liability for Nuisances

Recent court decisions have upheld the principle that the city's liability for committing a nuisance does not terminate with the construction of a means for eliminating it, but it must operate the plant effectively and is responsible for results due to inefficient operation or insufficient size.

In the case of Kneece vs. the city of Columbia, the Supreme Court of South Carolina has decided that a city must respond in damages for the negligent installation and management of an incinerator. The court held that the action was maintainable against the city even though there was no statute authorizing it and also held that the plaintiff had a cause of action based upon negligent operation even though he may not have suffered damage different in kind as well as in degree from what the general public has suffered.

In Mitchell Realty Company et al vs. city of West Allis, the Supreme Court of the state of Wisconsin held that, even though a city has created and maintains a sewage disposal plant of recognized type and was not negligent in its operation, it must respond in damages where it has created a nuisance by the discharge of sewage into a stream, and it is subject to injunctive relief, having as its aim the abatement of the nuisance.

The California District Court of Appeals held in People vs. city of Reedley et al that a permit issued by the State Board of Health authorizing a city to discharge sewage effluent into a river does not authorize the city to create or continue a nuisance or in any wise remit the power of the court to abate the same if found to exist.

## Sanitary Fill at Portland

Seattle, Portland and several other cities on the Pacific Coast have adopted the method of sanitary fill for disposing of their refuse, including garbage, and so far have found it to be more sanitary than others that have been tried, these others including practically all that have found any general acceptance elsewhere. In a communication dated October 31st, conditions at Seattle were described by C. A. Bigelow, commissioner of public affairs of that city; from which description the following information has been obtained.

The method of sanitary fill was first undertaken at what is known as the Fremont street fill. This was begun in February, 1923 and continued for practically 15½ months. The area filled was approximately 500x500 feet, of which the city owns approximately half and the other half is owned by private parties. Something over 46,000 tons was dumped at this fill. Considerable earth was available at the site for use in covering the garbage, and this was handled by means of a caterpillar tractor. In addition, about 7,800 cubic yards of earth from basement excavations was used here.

The garbage was dumped in layers approximately 10 feet deep, and this was covered with

about 3 feet of dirt as fast as dumped. These alternate layers of dirt and earth were continued until the fill had a maximum depth of about 40 feet, when a final layer of 4 to 6 feet of dirt was spread over the top.

Before this method was adopted this fill had been an offensive nuisance. The city does not collect garbage, and private garbage collectors had dumped here garbage and refuse of various kinds. The land was then private property, and it was acquired by the city through failure of the previous owners to pay the street assessment of about $6,000, which was considered to be greater than the value of the property. Since the fill has been completed the property has been appraised at about $18,000. The total cost of making the sanitary fill was $19,026. This fill is located within about 300 feet of one of the best residence streets in the city.

The second fill was started at Duniway Park. This has an average depth of 40 feet. All earth was hauled from basement excavations in the business district, the Park Department paying for the earth at the rate of 10c a yard. To date approximately 36,500 tons of garbage has been dumped here and 53,000 yards of earth, and the fill is about one-half completed. The first layer of garbage is about 25 feet deep with a 6-foot layer of earth, and the second layer about 15 feet with 6 feet of earth, the settlement amounting to about 12 feet. This fill to date has cost $11,900. It joins the beginning of one of the city's choicest east side boulevards. A part of the area where the fill has been completed is being used by the children of the neighborhood for a football ground.

In addition to these, the city has completed one small fill, is using a fourth fill and preparing a location for a fifth which it was expected to begin using before the end of the year 1924. "We find the method of disposal very satisfactory. Of course, the important thing is that sufficient earth must be available to keep the garbage well covered."

We understand that no burning of combustible matter is allowed on any of the fills, chiefly because of odors that would be given off. When the direction of the wind is from a fill to any residential district, the garbage is sprayed with a pinoleum preparation until it has been covered with earth. No garbage is received after 4:15 P. M., the balance of the day being used in spreading earth to cover the top and face of the fill.

## Incinerator Steam Utilized

Atlanta, Ga., has joined the very exclusive number of cities that have managed to derive an income from steam generated by the burning of refuse. We believe that Milwaukee is the only other city in the country that is now using steam so generated to its own financial advantage, although Savannah did so until a few years ago. The Georgia Railway and Power Company has contracted to take from the refuse incinerating plant of Atlanta, beginning December 1st and continuing for ten years, steam at the rate of 80,000,000 pounds a year, not less than 260,000 pounds each 24 hours and not less than 11,000 pounds an hour, a variation of 10% in the hourly rate of delivery being permitted; the steam to be delivered at a minimum gauge pressure of 170 pounds at the incinerator. The steam is to be dry, and the company may discontinue its use when it contains more than 1½% moisture.

It is believed by the city's engineers that it can supply double the above amount of steam, but if at any time it is unable to supply it at the above rates, the company can make up the shortage and charge the city not to exceed 20c per thousand pounds for the same. The price paid the city is 16c per thousand pounds for the first 70,000,000 pounds a year and 20c for anything in excess of that amount.

## Street Lighting in the United States

The United States Bureau of Standards has made a study of street-lighting practice in cities of the country having populations between 10,000 and 500,000, and questionnaires sent to the 730 cities coming in this list were made the basis of a report presented at the annual convention of the Illuminating Engineering Society.

In studying the data the cities were divided into ten groups according to population, the population range in no group exceeding 2:1. The poorest average illumination and the highest cost per capita were found in the smallest cities, the average cost per capita in this group being $1.02 per year. The least cost in any group is 74c., this being that group with a population range between 150,000 and 200,000. In this group the lighting is the poorest as well as the cheapest of that of any of the larger cities. The best illumination is found in the group of cities of 200,000 to 300,000 population, this group containing the largest percentage of state capitals, or five out of the nine cities in the group.

The questionnaires showed almost every imaginable combination of municipal and private ownership and operation of lighting plants and equipment. There are few cities in which the lighting system is owned and operated entirely by either the city or a public utility company. Individual business men, associations of merchants and citizens, and local city communities may own the lighting equipment, either entirely or in part; the city may own the distributing system and the lampposts, while the lamps and accessories are owned by the utility company, or conversely. On the same street there may be two separate systems or business arrangements for lighting as between the municipality, merchants association, and the local electric light and power company. There cannot be said to be any standard of practice in this respect.

The proportion of arc lights used varies greatly with the size of the city, being larger in the larger cities. Thus, in cities of from 10,000 to 20,000 inhabitants less than 20% of the lighting is by arc lights, while in the large cities it is 59% or more.

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## Notable Water Project

The Spavinaw water supply project, which is described in this issue, is notable in several respects although probably involving no radical departure from standard practice. Not the least interesting feature is the excellent work done by the city's engineer in expeditiously completing by municipal labor, a long and, in some respects, difficult pipe line construction which had been abandoned by the contractor. Another is the imperviousness of this same line. A few years ago the material of which this long conduit is constructed—reinforced concrete pipes—would have given it distinction; but, although the joint is comparatively new, such pipe for pressure lines is no longer a novelty but has become standard water works practice.

Other interesting details are the use of track in setting the pipe in subaqueous tunnel and leaving it there permanently; a steel bridge made to be moved ashore whenever a flood threatened; and method of constructing railroad crossings

## Illinois Pavement Cross-Section

As a result of the Bates road tests, the Illinois Highway Department designed, and many other state departments have adopted, a concrete pavement cross-section which is about three inches thicker along the edges than is the rest of the pavement up to a point 2 feet from each edge, where there is an angle in the under side of the cross-section. It has been calculated that this section permits making the body of the pavement thinner and thus saves an appreciable amount of concrete and consequently of cost.

Some contractors in Pennsylvania have criticized this cross-section and the statement of saving, as is noted elsewhere in this issue. They claim that if the subgrade is rolled (as presumably it always should be), it is impossible to maintain this angle 2 feet from each side form, but the roller persists in rounding it off. As the engineer, of course, calls for full thickness at the extreme edges, the result of course is a greater amount of concrete in the pavement than is indicated by the plan.

This is, we believe, no detriment to the pavement, although, when the contractors realize it, it will probably greatly reduce or eliminate any reduction in bids because of the new cross-section. In fact, it would seem to us that there would be a real advantage in this rounding, in that the pavement would be stronger therefor. It is well-known to mechanics and engineers that, when a structure of homogeneous material breaks, the break usually starts at a concave angle in its surface or perimeter, if one exists; and it has, therefore, seemed to us from the first that, assuming an angle in the surface 2 feet from the side of a concrete slab, there would be a tendency for the slab to crack along the line of this angle if anywhere.

If this angle in cross-section is objectionable, or, even if not objectionable, if it is impossible or impracticable for the contractor to exactly follow the plans, it would seem desirable to recognize

this and to modify the cross-section accordingly, substituting a curve for the angle in the cross-section which is now commonly specified.

## Contractors' Appreciation of an Engineer

Many editorials in praise of Clifford M. Holland, late chief engineer of the Hudson River vehicular tunnel, which has been given his name, have appeared in technical papers and the daily press, but we doubt if any of these would have been more appreciated by Mr. Holland than that which appeared in "The Bulletin," the official organ of the General Contractors' Association. Speaking for the contractors who had worked with him in carrying through this and other tunnel work, this editorial states that he had won their friendship

> not solely because of his tactful and courteous manner, but because he stood for the square deal for everyone associated with him or working under his direction. He was broad-minded enough to respect the other man's point of view and to adopt it if convinced it was the fair thing to do. Speaking of him shortly after his death a prominent contractor said: "If all engineers were like Cliff Holland, you would never hear contractors asking for an arbitration clause in their contract." Holland believed that the success of a job depended on the success of a contractor; that the contractor was a co-agent with him and that it was his duty to cooperate with the co-agent to make it a success. Men like him can get work done cheaper and better than those engineers who feel it their duty to fight the contractor in every doubtful point.

At the November meeting of the Executive Committee of the General Contractors' Association, it adopted by rising vote a resolution expressing regret for the death of Mr. Holland, testifying to his possession of

> those qualities of tact, courtesy and fairness that won the respect and affection of all those with whom he came in contact, socially or professionally. . . . As contractors, many of whom were privileged to come in contact with him, we honor ourselves in paying this tribute to Clifford M. Holland, who combined unswerving loyalty to his professional duty with that spirit of honesty that conceded even-handed justice in all his dealings.

Not all engineers can hold, or have the ability to hold, the prominent position occupied by Mr. Holland, but all can exercise this fairness in dealing with contractors, as well as with the engineers associated with them, which contributed greatly to the value of Mr. Holland to the officials and the public whom he served.

Some time ago a big railroad contractor said that, after preparing a bid upon any work, he took into consideration the man who was to be in charge of it. If he was an engineer known for fair dealing, he reduced his bid, but if, on the other hand, he had the reputation of trying to beat the contractor, he either increased his bid or refrained from bidding altogether. To a greater or less extent this plan is undoubtedly followed by all contractors of wide experience, and it therefore results that the engineer with a reputation for fair dealing may, through this reputation alone, save for those employing him much more than his salary. Such a reputation may well be worth more to an engineer than his knowledge of engineering principles or practice; and the realization of this is perhaps one of the most important truths to be impressed upon young engineers just starting out in their profession.

## William P. Blair

One of the most widely known men in the paving field for the last quarter century was William P. Blair, vice-president and for many years secretary of the National Paving Brick Manufacturers Association. Mr. Blair had been in very poor health for about two years past and died on December 23rd at the age of 76 years. He was active until the very end, having attended the meeting of the Highway Research Council in Washington, December 4th and 5th, and a meeting of the Ohio Good Roads Federation the following week.

He was the founder and organizer of the National Paving Manufacturers Association and for many years was a paving brick manufacturer. He was an active member of the Roadbuilders Association, Society for Municipal Improvements, Society for Testing Materials, state engineering societies of Ohio, Indiana, Illinois, Michigan, Wisconsin and Iowa and a number of other societies and highway and automobile clubs. Among the members of these, he numbered by the hundreds friends who appreciated his active interest in highway matters and the unquestioned sincerity of the opinions he so vigorously expressed.

## City Engineer and City Government

Much has been said recently of the desirability of activity by engineers in civic affairs, including politics, while others believe that engineers holding city positions, at least, should be entirely free of politics. Which ever idea is entertained, there can be no question that a city engineer should be thoroughly informed concerning the city government. We were, therefore, greatly pleased to receive recently a copy of a pamphlet entitled, "What You Should Know About Your City Government," consisting of a series of articles on the government of St. Joseph, Mo., written by its city engineer, W. K. Seitz. Mr. Seitz originally published this as a series of articles in the local paper, and they have been considered of sufficient value to the voters of the city to call for their publication collectively in pamphlet form.

The articles deal with the charter, the duties and powers of the mayor, of the council, the board of public works, the board of park commissioners, the board of health, the fire department, the legal department, the engineering department, and various officials such as assessor, auditor, etc. He also describes the workings of the initiative, referendum and recall. The public library system, the city's finances, the work done by the welfare board and by the police department are some of the other subjects covered.

The matter is excellently arranged, clearly written and summarized, so that any intelligent citizen can understand any of the essential features of the city's government.

# Water Purification for Small Cities*

**For some small communities a safe and palatable supply can be obtained more cheaply by purifying a surface supply than from deep wells.**

Is it practical for a city with as little as 1,000 population to consider the installation of a water purification plant? A general answer of "yes" or "no" applicable to all cases is impossible; but it certainly is true that, where other supplies are unsatisfactory, the development and purification of a surface supply should at least be considered in every case. Most Iowa cities can obtain a satisfactory supply from wells, but there are sections where the well water is objectionable because of tastes and the presence of iron and other minerals in solution, as well their unsatisfactory bacteriological condition. Some wells which originally furnished safe water have deteriorated through the corroding of the well casing or the erosion of channels through the overlying limerock, permitting the water to become contaminated.

As a result of these conditions, three cities in the southern half of Iowa during the past year installed purification plants and several in the northern half have installed softening and iron-removing plants. As an indication of what can be done, it may be instructive to relate the experiences of several cities during the past few years.

The city of Adel, population 1,500, for years used a supply from a shallow well carrying a great deal of iron, of undesirable hardness and of disagreeable taste. After investigating all available underground supplies in the vicinity, the council decided to use the water from Racoon river, on whose banks the city was located, purifying it with a small rapid sand filter plant. The city now has a plant with a capacity of 120,000 gallons a day. The water is first pumped from the river to a small aerator, from which it flows by gravity into a coagulation basin 9 x 32 feet by 12 feet deep, where the water is treated with alum and allowed to settle. Thence it flows by gravity through a sand filter 5 x 8 feet and enters a clear well beneath, which has a capacity of about 4,000 gallons. From the clear well the water is pumped into the distribution system, liquid chlorine being applied at the intake of the high-duty pump. The total cost of this plant, including chlorinator, was $11,000, for which the city obtains a comparatively soft, clear, safe water.

Sigourney some years ago obtained a supply by carrying a watermain to a small river a good five miles away, where a natural purification plant was to be developed. The attempt to develop a natural filter was a complete failure, but as no other supply was available and the resources of the town had been completely drained, the city put up for years with a very unsatisfactory, dirty, raw river water that could not be used for drinking or culinary purposes. Although several engineers advised the council to continue using the river water by installing a modern rapid sand filter plant, on the ground that the deep well water would contain a great number of objectionable salts, the council was so disgusted with its past experience with a surface supply that a contract was let for a deep drilled well. This well, drilled within city limits, a pump house and pumping equipment cost about $30,000. The water is very hard and contains such an amount of mineral salts that it cannot be considered satisfactory for drinking purposes; in fact, the public prefer to use private, shallow, contaminated wells.

Compare this with the case of Adel, which secured by filtration a satisfactory supply at a cost less than half the cost of a well supply for Sigourney. However, as a rule, it may be said that the first cost of a filter plant and the development of a surface supply will exceed that of a deep well; but there are exceptions to this as in the cases above, and in places where a satisfactory well supply is impossible, a good surface supply is cheap at any price.

The one chief argument which discourages the establishment of a surface water supply is the operation of a purification plant. Unless the operation is careful and intelligent, the plant will prove a failure. "I do wish to emphasize, however, that a small city need not think it must necessarily employ a high-priced engineer to operate a water purification plant. A conscientious, industrious, intelligent man may be placed in charge and taught in a very short time all that is necessary. In a small city the plant may need to be operated but half a day, and the operator might, therefore, be a commissioner of streets or occupy some similar office with duties which could work in well with those of filter plant operator."

Much can be said concerning the matter of cost of operation, and it is no doubt true that it would cost more in some places to operate a purification plant than to operate a well supply. But every waterworks system, no matter how simple, must have some sort of a caretaker in charge. Most of those in Iowa have a caretaker who devotes to the plant anywhere from one to twenty-four hours per day. The same man who takes care of a well system, if intelligent, can with a little more time take care of a properly equipped purification plant. At Adel the operator spends about one-half his time at the plant and the remainder of his time is occupied with waterworks extensions or acting as a street commissioner.

The underground water supply of Iowa is rapidly diminishing, and it is only a matter of time when it will be exhausted in some places.

*Condensed from a paper before the Iowa Section, American Waterworks Association, by H. V. Pedersen, State Sanitary Engineer of Iowa.

Moreover, the well supplies of many Iowa municipalities have for years shown a marked increase in the amount of objectionable impurities present. These municipalities are approaching, if they have not already reached, the point where they should at least seriously consider substituting a purified surface supply for the well supply.

# Air Lift Pumps

**Conclusions from experiments conducted by the University of Wisconsin. Each pump must be designed to meet the conditions of the case.**

Experimental work on air lift pumps was begun in 1919 by the Engineering Experiment Station of the University of Wisconsin, cooperating with John C. White, chief engineer of State Power Plants, and W. G. Kirchoffer, consulting engineer. Tests were made especially on the design of foot pieces, and as a result it was concluded that, "if certain fundamental and simple principles were observed in the design of a foot piece, it appeared to give essentially the same performance as any other one; in other words, the foot piece is relatively the minor consideration in successful air lift performance. The conditions in the eduction pipe, where the energy of the air is expended in producing motion of the water, are the factors which really determine the success or failure of design for economical operation of the air lift pump."

These tests suggested further experiments with larger apparatus, and such tests have been carried on by the University since that time. The manner of conducting them and the conclusions from them are set forth in Bulletin No. 1265 of the University of Wisconsin entitled, "Experimental Study of Air Lift Pumps and Application of the Results to Design," which report has been prepared by Clayton Norman Ward, assistant professor of hydraulic engineering, and Lewis H. Kessler, instructor in hydraulic engineering and who had worked upon the problem as a thesis subject while a student in the University.

The bulletin explains in details and with diagrams the experimental apparatus used and gives in tabulated form a log of the several tests run, the whole occupying 166 pages and several diagrams.

The conclusions reached by the investigators are as follows: "Since the conditions to be encountered in the pumping of any two wells are not usually exactly similar, each pump installation requires special attention. As in the case of centrifugal pumps or hydraulic turbines, the air lift pump will not give reasonable efficiencies if improperly designed or if used under conditions for which it is not adapted. The limits of length and of diameter of eduction pipes which will give good efficiency in a particular well are rather narrow.

"Some of the other important conclusions reached in this study are given below:

"1. The efficiency of an air lift pump depends primarily upon the conditions of flow in the eduction pipe.

"2. Great refinement in the design of foot-pieces is not necessary. Small air openings for dividing the air into fine bubbles, and special devices for mixing the air with the water are not necessary. There should be no central nozzle or projecting part to obstruct the flow of water in the foot-piece.

"3. A particular pump in a given well gives maximum efficiency at some particular rate of pumping. The smaller the pump, the narrower the range of rate of pumping in which high efficiencies may be obtained.

"4. The per cent submergence required for maximum possible efficiency ranges from 65 to 75 per cent in most cases. The lower range of submergence is approached in wells with a high delivery head.

"5. Very small pumps give relatively high efficiencies with low submergences. A 1-inch pump shows good efficiency at a submergence as low as 45 per cent.

"6. It is possible that the air lift pump may be satisfactorily adapted to the pumping of small wells such as are used for rural water supplies.

"7. The combined friction and slip losses due to the flow in eduction pipes follow a different law than that which governs the flow of water, or of air, in a pipe.

"8. There is a comparatively simple relation between frictional losses and velocity of flow in an eduction pipe for any particular mixture of air and water.

"9. At a given velocity of flow in a given eduction pipe, the losses increase as the ratio of volume of air to volume of water increases.

"10. There is a particular velocity of flow for any ratio of volume of air to volume of water which is accompanied by a minimum loss of head. Losses increase very rapidly when the average velocity is reduced below the above velocity. The rate of increase of losses with increase of velocity depends upon the diameter of the eduction pipe. Relatively high velocities may be used in large eduction pipes. In the small eduction pipes, losses increase rapidly with increase of velocity above the velocity which gives maximum efficiency.

"11. Special attention should be given to the making of smooth joints in eduction pipes. Changes from one size of pipe to another should be gradual. A sudden enlargement is very detrimental to efficient operation. Eduction pipes should be vertical. A horizontal travel of a mixture of air and water results in the separation of the air from the water.

"12. In many cases, the writer believes that eduction pipes of uniform diameter could be designed to give better efficiencies than are now obtained with those of varying diameter. This is particularly true of pumps used in wells in which the delivery head is relatively low.

"13. Many pumps of varying diameter are designed on the basis of a straight line hydraulic gradient from the foot piece to the point of discharge. This is a faulty assumption which results in the using of velocities that are entirely too high in the lower sections of the eduction pipe.

"14. The loss of head-velocity analysis is the most satisfactory method of correlating experience with air lift pumps. This method makes possible the extension of experience to the practical design of pumps to operate under conditions different than those encountered in the tests.

"15. Many experimental tests of pumps do not include sufficient data for a complete analysis of the conditions of operation. The temperature of the liquid pumped should be recorded in field tests. Pressure measurements should be taken, when possible, at points in eduction pipes where pipes of different size are joined. These pressures may be obtained at small cost, if one-quarter-inch gage pipes are installed when the eduction pipe is being assembled and lowered into the well. Pressure observations then can be made in the same way that the level of water in the well is usually obtained by the use of "tell-tale" pipes. There is particular need for further experimental tests on eduction pipes of large diameter.

"16. Test models of air lift pumps less than 40 feet in length are apt to give results which are different than those obtained with long pumps. Losses which are relatively insignificant in large pumps become important in short air lift pumps."

Discussing air lift pumps in general, the author states that the particular merit of this pump is its mechnical simplicity. There is not a moving part below the surface of the ground; it is not affected by sand or grit carried in suspension in the water pumped, and it can usually be designed so as to give a greater rate of discharge from a well of a given size than any other type of pump that could be installed in such well. Also, where there are several wells in a system, each may be operated and controlled from a central station. Repairs can usually be made with a shut-down of the pump of much shorter duration than is required of other pumps. On the other hand, its efficiency is lower than that obtained with certain other pumps; but, due to the difficulty in maintaining such pumps, it is doubtful if the efficiency of a properly designed air lift pump is, in the course of continued operation, much less than that which is actually attained by other pumps. Another objectionable feature is that an air lift pump cannot ordinarily be used economically in a well in which the depth of liquid is not greater than the height through which the liquid is to be raised. Its efficiency is very low when the conditions in the well prevent the installation of the proper air lift pump.

## For Uniform Highway Laws

In December the National Highway Safety Conference, assembled at the request of Secretary Hoover, discussed the means that seemed practicable for securing greater safety from accidents on the highways. One of the important means is, they agreed, the securing of uniform highway laws by the forty-eight states, 3,000 counties and 13,000 cities, towns and villages in the United States.

Some of the moves decided upon as desirable were: Uniform regulations limiting speed on city streets to 15 miles an hour, and 35 miles on open roads. Provision of parking spaces on county highways every 300 feet, where a car can stop entirely off the main road. Elimination of sharp curves on main highways and the banking of all curves. Guard railings on embankments. The elimination of narrow one-way bridges. Placing of signs along all highways indicating the lawful speed.

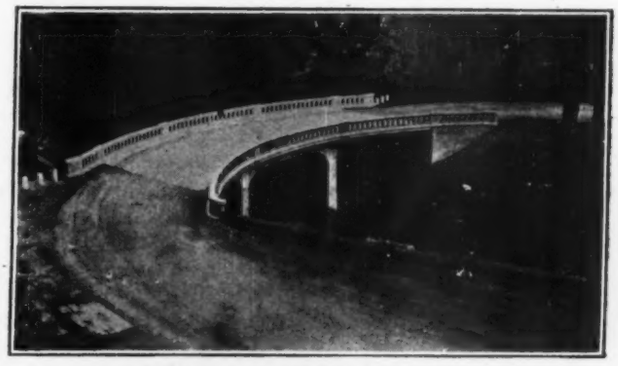
# Washington Highway Notes

**Construction by force account. Department locates road materials. Keeping roads clear of snow.**

The State Highway Engineer of Washington issues his reports biennially, and the one for the two years ending September 30, 1924, has recently reached this office. In this report James Allen, the state highway engineer, states that since the repeal of the one-mill public highway levy in 1923, all of the state funds for construction and maintenance of highways are being derived from automobile license fees and gasoline tax, which, for the year 1923-'24, amounted to approximately $8,398,000.

Construction of public works by force account by the state or municipalities of the state is permitted, but under certain conditions that are unusual. Whenever performed by any method

CLIMBING THE RIDGE IN STEVENS COUNTY, WASHINGTON.



CURVED BRIDGE ON MOUNTAIN ROAD, SKAGIT COUNTY, WASHINGTON.

other than contract and if the estimated cost exceeds $2,500, a description of the work and an estimate of the cost must be published in a newspaper of general circulation at least fifteen days before beginning the work, the estimate showing the quantity of each class of work, unit cost, time limits, total estimated cost of labor, materials, provisions, supplies, equipment rentals and purchases, industrial insurance and medical aid, superintendence, engineering, clerical and accounting service, the value of use of equipment owned, and other estimated expenses in the execution of such work. Within sixty days after the completion of the work a certified copy of the actual cost of these items, together with a certificate of the engineer that the work was executed in accordance with the plans and specifications on file, or describing any deviation therefrom, shall be filed and within twenty days after such filing a copy of the final record of cost shall be published in the same publication in which the original estimate was published.

The Highway Department, preliminary to asking for bids on any piece of work, searches for deposits of sand, gravel and rock that might be suitable for use in the project, tests representative samples in the laboratory and, if these are found satisfactory, digs test pits to determine the volume of the material available. If the material can be used in accordance with the standard specifications or under a special specification, the property is leased or purchased by the state. The contract does not require the contractor to use this or any special material but he may use any material that complies with the general specifications, which require first-class materials. But the Department prepares the way for securing the materials at the least cost in order that the cost of the work to the state may be kept at a minimum. Research in materials, particularly in fine and coarse aggregate, is continued throughout the year and contractors are advised regarding the possible sources and naturally select the materials that can be placed in the structure for the least money and bid on the work accordingly.

The department also considers the matter of transportation. For example, plans were made in the summer of 1922 for completing a section of the Pacific Highway in 1923. No local sand was found available and local gravel for only one 4- or 5-mile contract. A study of transportation facilities showed it would be impossible to complete the work in 1923 without storing sand and gravel on or near the job before the beginning of work in the spring of 1923. Accordingly, plans and specifications were prepared for furnishing and storing the aggregate and contracts awarded in the fall of 1922. The contractors worked all through the winter and spring of 1922-23, two special freight trains being operated in each direction each day for a considerable time to insure the delivery of the material in time for the construction of the pavement. A somewhat similar condition confronted the Department in the fall of 1924 in southeastern Washington where local materials are scarce and a contract was awarded early in the fall for delivering, during the present winter and the spring of 1925, the sand and gravel necessary for next year's work in order not to overtax the railways and the sources of the sand and gravel during the construction season.

Keeping highways open during the winter seasons is a real problem in the Western mountains. During the winter of 1922-23 Snoqualmie, Bluett and Chinook Passes were closed for the entire winter and in April, 1923, the Department let a contract to open up 8 miles through the Snoqualmie Pass, removing all snow and ice from the roadbed for a width of 12 feet, the work to be completed by May 10th, the contract price being $7,000. The contractor used a steam shovel equipped with a special snow dipper. Last winter the Department removed snow with its own forces, using a tractor plow pushed by a 10-ton and 5-ton Holt tractor hooked up in tandem. The power was too great for the strength of the plow, which went to pieces, and the Department was expecting to build a special one of ¾-inch material heavily reinforced, strong enough to lift and break up the snow as well as take care of logs and rocks encountered. Last winter quite a few logs buried in the snow were discovered only when hit by the plow.

A total of 476 miles of highways was cleared of snow last winter at a cost of $10,157, or $21.34 per mile. This cost varied from $2 a mile where the snowfall was light, to $165 in Snoqualmie Pass. In one section 20 miles long 128,000 cubic yards of snow was removed at a cost of 2.57 cents per cubic yard, exclusive of cost of equipment and repairs. The high cost of snow removal in Snoqualmie Pass was due to the soft subgrade, lack of protection against snow falling in the caterpillar tracks, breaking of the pole connecting the two tractors, ice caused by running water where ditches had been obstructed by slides, the large amount of repair work to the plow, and radiator breakage. At the time of writing the report it was the opinion of the engineer that the most feasible method of removing deep snow in the summit passes was the use of a steam shovel and special bucket.

## Contractors' Questionnaire in Colorado

Colorado was the first of the western states to adopt the questionnaire system of selecting contractors for highway work, and it is said that the result has been a decided improvement over previous conditions. Before it went into effect in 1924, few projects were completed within the time limit set, and several contractors did not finish their projects at all, but this was done by bonding companies. The questionnaire eliminated all but competent contractors, and the result this year has been that the state has almost caught up with its building program.

The motorists of the state were especially incensed at the delay in previous years in carrying on new highway work, during which time they

were compelled to use detours, many of them very rough, in some cases for two years at a stretch. It is said that last year five miles of the Pikes Peak Ocean-to-Ocean Highway was closed to traffic while a contractor was working at it with a force of men and machinery ridiculously insufficient for the size of the job.

The contractors' questionnaire was adopted by Colorado chiefly through the efforts of Major W. R. Richards, executive secretary of the Rocky Mountain branch of the Associated General Contractors. It requires an inventory of the contractor's financial resources, experience and equipment, the questions being similar to those used in other states where the system has been in use for two or three years.

## Electrical Industry in 1924

Two of the largest manufacturers of electrical appliances, The General Electric Company and the Westinghouse Electric & Manufacturing Company, have published reviews of the business done during the year 1924. The former is in the form of an article appearing in the January issue of the General Electrical Review entitled, "Some Developments of the Electrical Industry During 1924." The other is a pamphlet of 45 pages entitled, "The Engineering Achievements of the Westinghouse Company During 1924."

The former states that the total volume of production for the electrical industry during the year was somewhat below that of 1923, but exceeded all previous records for central station equipment, traffic signaling, street lighting, industrial heating and some other classes of apparatus. Most of the developments were along conventional lines, but several improvements were made tending to increase efficiency.

The Westinghouse pamphlet goes into great detail in the matter of improvements made in all branches of electrical industry. The features of special interest to public officials are those having to do with street and highway lighting. Several new designs of lighting fixtures have been brought out, the most important of the developments having been the introduction of a successful and practical asymetric distribution of light, which has already been described in PUBLIC WORKS. Reference is made to the highway lighting unit which we described a few months ago. The company is prepared to furnish concrete lighting standards of various designs and heights manufactured by the centrifugal process and known as "hollowspun" standards. The company naturally refers with pride to its work in the development of wireless telephony and especially its K.D.A.A. broadcasting station.

## Motor Truck Production

While the production and sale of passenger automobiles in 1924 was approximately 10% less than the record made in 1923, the sale of motor trucks came up to within 4% of the 1923 record. The total production of motor trucks in 1923 was 376,293, while the production for 1924 was approximately 365,000.

There are probably at least two or three reasons why the motor trucks made a better showing in this respect than the passenger automobiles. One is that the Government some months ago reached practically the end of its distribution of trucks left from the war, and the deterioration of those previously distributed and the increased needs resulting from the enormous highway construction program have made a demand upon manufacturers for new trucks to meet this need. Another reason is that the truck has demonstrated itself to be a necessity in many lines of work, while to a large extent the passenger automobile is a luxury which feels very quickly any falling-off in the business profits of the country; besides which, the passenger automobile has undoubtedly approached nearer the saturation limit than has the motor truck.

## Contractors and the New Concrete Section

Since the publication by the Illinois State Highway Department of the new section for concrete roads that had resulted from its road tests, several states have adopted this section. A practical difficulty in construction of it is described thus by the Juniata Company, road contractors of Philadelphia.

Tests have conclusively shown the necessity of thickened edges for concrete roads and with this we take no exception. It is when, with this in view, a cross-section for subgrade is called for that is impracticable in field work to maintain, that we contractors feel warranted in suggesting a change.

Constructive criticism can hardly be taken amiss, therefore, we feel free to suggest to the powers that be in the engineering and designing of state highways, that a change be made in the present cross-section of subgrade for future work.

It has been the general practice during this last construction year to require concrete either eight, nine or ten inches on the sides and five, six or seven inches in the center, which latter thickness follows the crown of the road for either five, six or seven feet on each side of the center joint, depending on the width of the road. Here a sharp break is made in a straight line to the required depth at sides.

This is where the rub comes in. In practical construction it is absolutely impossible to maintain this section under the rolling that is necessary. On repeated field tests on several of our contracts this year we found the subgrade in all cases from ¼ inch to 1½ inch low at this break, and no matter how carefully this was brought to grade, the final rolling would invariably flatten this out to a regularly crowned subgrade. If this point in grade were purposely left high, the rolling would squeeze the earth to the forms or towards the center, where the final tests with a subgrade tester would show this as high, compelling the removal of this earth and still leaving the point of breakage low, requiring 7 per cent to 8 per cent additional concrete over the theoretical quantity required. Taken in conjunction with the additional ¼ inch required in strike off templates, this causes overruns on cement, sand and stone up to 10 per cent, for which no payment is allowed.

We are not alone in our troubles, as we are told other contractors working on this section have encountered the same condition. Naturally a contractor having had this experience will allow for this in future bidding; but, the new contractor, of which the woods are always filled, will estimate his quantities on the plans, and donate this extra to the State.

Would it not be a more fair and equitable plan to revise the subgrade section to a regular crown, or in other words, show on the plan a typical subgrade section that all contractors are securing now, in place of the impossible section as called for?

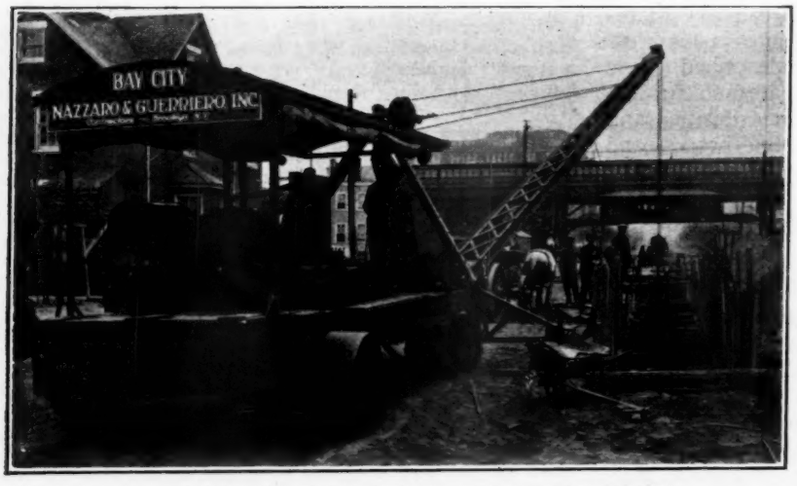
# Excavating Brooklyn Sewer

A segment block sewer of 36 inches diameter is being constructed in Avenue P, Brooklyn, N. Y. between Gravesend Avenue and Ocean Parkway by Nazzaro & Guerriero, Inc. as contractors, in which methods somewhat out of the ordinary are employed in the excavation.

The sewer is being laid in a street which has been surfaced with about 1 foot of oil-treated macadam, underlying which is about 3 feet of clay and the balance a coarse sand carrying very little gravel. The sewer is being laid in a trench about 7 feet wide and running about 18 feet deep. The easily handled clay and sand soil suggested the use of machinery, but owing to the hard macadam surface, the contractor decided not to use an ordinary trench machine. Instead, he used an excavator or crane, a scoop bucket on one end of a lever arm at the end of a boom being used for removing the material to a depth of about nine feet. The compact nature of the top 3 or 4 feet permitted the trench to be carried to approximately 9 feet depth before sheeting became necessary, but the trench was braced as promptly after the excavation as possible and before attempt was made to to carry it any deeper. For this top 9 feet, the sides of the trench are cut perpendicular and the sheeting crew follow immediately behind placing 2-inch sheeting held in position by rangers 4 in. x 6 in. x 16 ft. long and 6 in. x 6 in. cross braces 6 feet long. This sheeting is kept up as close as possible to the machine to prevent any caving and, in fact, it is necessary at times to stop the excavating to allow the sheeting to catch up with it.

After about 200 feet of trench has been opened up in this manner the trencher boom is removed and a 30-foot crane boom takes its place, three men making the change in less than two hours' time. The machine is then run back along the trench to the end of the section which had previously been dug to the full depth and is set up 5 feet from the sheeting, and the crane boom is used for handling a clamshell bucket by which the trench is carried to the full depth. In this work, where the boom is always on one side of the machine, a folding outrigger is swung out on the side toward the trench. The excavation is then continued by lowering the clamshell between the trench bracing, biting a bucket full of the coarse sand, raising it and depositing it on the opposite side of the trench. In doing this work the boom is set to swing on a 30-foot radius which does not ordinarily need to be changed, the machine moving ahead as the excavation proceeds. As the trench is being lowered the sheeting is continuously driven down to prevent the caving of the sand. When a section of trench about 200 feet long has been excavated to its complete depth and the sheeting all driven, the machine again goes over the bottom bringing it to approximately exact grade for laying of the sewer.

EXCAVATING UPPER HALF OF TRENCH, AND SHEATHING




REAR VIEW OF CRANE USING CLAMSHELL

The same machine is also used for backfilling over the completed sewer, using the clamshell to remove the material from the further side of the trench and depositing it on top of the sewer. This backfilling is usually done when the excavation work has been temporarily completed and while the sewer is being laid. This one machine is, it is seen, able to perform these three stages of the work and still keep ahead of the masons laying up the sewer, thus saving the contractors the expense of investing in duplicate or triplicate plant. The machine used is a Bay City Model 16-B convertible excavator, and a Blaw-Knox clam-

EXCAVATING IN SAND USING CLAMSHELL

shell bucket is used. Finally, after the backfilling has been completed, the same machine is employed, using the crane boom, for drawing the sheeting.

## Iodine as Preventive of Goitre

Reference was made in "PUBLIC WORKS" about two years ago to the adoption by Rochester, N. Y., of the use of iodine in the public water supply as a means of preventing goitre. This practice has been continued and several papers concerning it have been read before the various waterworks associations, as noted in this journal, and interest in the subject is beginning to be manifested by the general public. It may be of interest to review here briefly the ideas and opinions of waterworks men, as brought out in the Ohio Conference on Water Purification.

Goitre was stated to be due to absence of iodine in the human system, which condition is found in localities considerably removed from any large body of salt water. O. P. Kimball stated that approximately 1 mgm. of iodine per day, or from 100 to 200 mgm. administered twice yearly, is sufficient to keep the thyroid saturated and prevent goitre. It was his opinion that treating the public water supply with sodium iodide involved considerable waste, in that only about one-fourth of 1% of the amount applied to the water is actually imbibed. Adolescent goitre, he thought, could best be controlled through the schools. In Switzerland chocolate tablets containing 0.5 mgm. of iodine have been administered to pupils of the school at the rate of one tablet per week for two years. Iodized table salt had been tried but found to be less satisfactory. On the other hand, Clarence Bahlman recommended the use of iodized table salt in preference to treating the water supply. He stated that to treat the supply of Cincinnati on the basis employed by Rochester would cost $10,000 a year, adding 10% to the present cost of operating the filter plant.

J. W. Elms stated that during two weeks in the fall of 1923 approximately 75 parts of sodium iodide per billion was applied daily to the water supply of Rochester. The iodide was placed in a bag which was suspende in the water back of the dam at the entrance to the reservoir, the entire 16.6 pounds dissolving and entering the reservoir within a few minutes. Analyses of the tap water in the city showed the iodine content to increase gradually from 4 to 50 parts per billion during the treatment, and gradually decrease for about two-and-a-half weeks after the treatment had been discontinued. The maximum of 50 parts per billion continued for only four days. The average during the treatment was about 30 parts. The cost of treating the water of a large city would be greater, he estimated, than treating individuals directly by some of the methods suggested. Even the treatment of the water, however, would apparently cost not more than 10c per capita per year, so that the amount of waste involved is not financially a serious one. Some physicians, however, have expressed the opinion that the iodine salt added to the water might be neutralized by other matters carried in solution by the water, so that it was not certain that consumers of the supply would receive any benefit from the iodine salts, or at least as much benefit as though it were administered directly as a medicine or in prescribed doses in candy, food, etc.

## 1924 Construction Costs

The cost of construction, chiefly that of buildings, during the year 1924 has been summarized by the Associated General Contractors of America, which states that the average prices paid by contractors for materials during the year was about 4% less than during 1923, while the average labor rate was about 6% higher. There was, however, little change in either of these during the year, and the average cost of construction, on the basis of costs in 1913, ranged from 201 to 205%, the average for the entire year being 202%, and the index number for December was 201. The amount of construction during 1924 was about 3% greater than during 1923.

Like most other students of the subject, those making the study of the figures for this Association seemed to think that construction costs have practically reached a constant level and that there will be little change from present prices, at least during the next year or two.

## John M. Diven Dead

John M. Diven died on January 4th, aged seventy-three. He was widely known among water works men as the secretary, for twenty-five years, of the American Water Works Association. In February of last year he was made its secretary emeritus.

He was secretary and treasurer of the Elmira water works for thirty-three years, superintendent of the Charleston, S. C., Light and Water Co. for seven years, and superintendent of the Troy, N. Y., water works for eight years.

# Street Traffic as Basis of Street Design*

**Methods of estimating future traffic in city streets and of designing street system to accommodate it.**

By Ernest P. Goodrich†

All problems as to traffic can be related to population—its distribution and activities.

The first step in determining future traffic and the means of handling it is to reach a conclusion as to the future total growth of the community or communities under consideration. Certain laws of population growth have been determined with fair conclusiveness.

Growth is at first accelerated from a high birth rate and heavy immigration. The birth rate falls relatively to the death rate and competitive conditions restrict immigration.§ Changes in economic conditions (such as the effect of the whaling industry on New Bedford) have large effect.

The second step in determining future traffic is to assume the distribution of population within each community. Studies of population distribution show that it follows well-determined laws.

The average resident density varies inversely with the distance from the center of the community, except for a flattening of its curve at the center. It varies similarly with distance from subcenters and main traffic and transportation routes. It is greatly influenced by topography and such artificial factors as large parks, cemeteries, reservoirs, railroad yards, etc. Immediate growth is affected by land values, the state of development of public utilities and transit facilities. It will be stabilized and sometimes limited by zoning ordinances and local restrictions.

Having fixed upon the probable distribution of the homes of the people, the location of their daily activities must be similarly determined. Definite ratios have been found to exist between the areas which need to be set aside for residences, business, industry, parks, and circulation. 4,000 sq. ft. of land will house an average family of five persons. A 25-ft. front local store will care for 100 persons. It takes about 2,000 sq. ft. of factory land per worker. In the average, eventually about 20% of the population will probably be employed industrially. These are typical general conclusions, which must be determined separately for each specific community. Topography evidently is a large factor in fixing industrial areas, railroad rights-of-way, etc., and zoning ordinances will assist in stabilizing conditions so that estimates of future land use will be fairly accurate.

Business methods and activities are the next factors requiring study. When each family manufactured its own clothes, the traffic could have been measured in one or two vehicles per family per month, used to visit neighbors, attend town meeting, or go to court. Within present memories, it was common practice for farmers to go to town on Saturday afternoons, thus producing two vehicles per family per week. Studies of many communities show one vehicle per family per day as the present day city traffic which visits residential areas. Certain figures with reference to local commercial and to large industrial areas in one typical city are one vehicle per day per five-foot front and per 1,000 sq. ft. respectively. This traffic is largely automobile and will grow as some function of the local registration (ignoring through traffic for the moment). In various cities the traffic has been growing from the one-half to the seven-eighths power of the registration. As far as can be ascertained from the meagre collateral statistics which are available, the annual average mileage per car has been about constant during the past ten years. It is hardly expected that it will increase greatly—furthermore the car ownership is rapidly approaching a saturation point which is readily determined for each state and for most large cities.

In order to estimate future traffic, it is essential next to know the average length of each trip, or the proportionate number of trips of different lengths. It is well known that short trips are much more numerous than long ones, both in city traffic and in that in the country. Typical data has been supplied by the Connecticut state highway traffic census. The following table gives the results thus obtained.

| *Length of Trip, Miles* | *% of Total Traffic* |
|---|---|
| 0-9 | 36.9 |
| 10-29 | 30.5 |
| 30-69 | 18.4 |
| 70 and over | 14.2 |

Generally speaking traffic quantity varies inversely with the length of trip. This is disclosed by analyses of traffic around large cities, from studies of ferry traffic, etc., as well as from that from Connecticut.

### TRAFFIC DENSITY MAPS

A traffic density map can be constructed on the basis of such data as that above described. The community is first divided into areas of as homogeneous use as possible, and as nearly equal in traffic origination. The traffic between each two such areas is then computed on the basis of their size, type and distance apart. Usually it is not necessary to take account of distance except in the largest cities and in regional and state studies. A convenient method (*) is to place pins on a map so located that differently colored strings can be run from each area to each other one by the best route. Such a study brings out

*Paper before the American Society for Municipal Improvements.

†Consulting engineer, New York City.

§The term immigration includes interstate shifts and the rural-urban movement as well as foreign immigration.

*This method was invented by George W. Melville in the writer's office.

clearly all needed short cuts and other possible improvements in the highway system.

Such studies based on present-day conditions have been compared directly with traffic tallies and found to check with surprising concordance when carefully done. Obviously, in small areas, all through traffic must be segregated and separately treated. This can be done by the same general method. The latter is obviously also applicable to the study of future traffic five, ten or forty years hence, with correspondingly wide possible divergencies due to the impossibility of determining the future population, its automobile ownership and other future factors with precision. Such a method is obviously more trustworthy than would be a simple guess. Seasonal and hourly variations in traffic must be considered and factors applied to convert average data to that of the maximum hour, which latter must be used in determining street widths. Traffic tallies and theoretical studies of acceleration rates, braking distances, etc., afford data as to the numbers of vehicles which can be operated over any given type of pavement of any assumed width. Data of this kind were presented before the Fourteenth National City Planning Conference in Springfield in 1922. Much information has been secured since that date but it all points to the figures there enunciated as conservative.

With such traffic numbers per moving line per hour and with the probable future traffic estimated (as above described), it is a relatively simple matter to lay down plans for future streets and roads adequate to care for future traffic requirements.

With certain assumptions as to population, commercial and industrial density, it is an easy matter to determine the spacing and general arrangement of main thoroughfares. Thirty-foot roadways serving single-family houses on lots 50′ x 100′ should feed into main thoroughfares spaced not to exceed 6,000 ft. apart. In two-family districts the spacing should be reduced to 4,000 ft., and for the average multi-family house district 2,500 ft. should be the maximum spacing between main thoroughfares. In industrial districts main thoroughfares should not be spaced to exceed 1,500 ft. and they should theoretically increase by units of 10 ft. for each 750 ft. in length as any street approaches the center of a community or other traffic destination point. If attention is turned to transit facilities, including the street car and the motor bus, it is believed wise to space thoroughfares one-half as far apart as the figures above given, permitting cars and buses to operate on alternate thoroughfares. All other traffic has been ignored in esblishing these figures and additional streets and street width must be provided to care for it.

## Ash Collection in Pennsylvania

A short time ago statistics were obtained concerning the methods of collecting and disposing of garbage and ashes in the third-class cities of Pennsylvania by the Secretary of Internal Affairs and the Director of the Bureau of Municipalities of that state. From the information obtained by them we have summarized the following concerning ash collection:

The report contains replies from thirty-nine cities varying in population from Erie, with 115,614, to Corry, with 7,736. Ten of these cities stated that ash collection was done privately, these cities, in the order of their population. being Erie, Wilkes-Barre, Johnstown, Altoona, McKeesport, Williamsport, Hazelton, Uniontown, Connellsville and DuBois. In three—Harrisburg, Easton and Coatesville—ashes and rubbish are collected by the city; in Reading and Allentown the collection is private; while in Chester and York they are collected by contract. Seven cities, Lancaster, Newcastle, Butler, Monessen, Bradford, Meadville and Clairton, report no ash collection. The other fifteen cities make no report concerning ashes, and it would seem probable that in the majority of them also there is no regular ash collection.

As to the cost of the service, the appropriations made for ash collection and disposal were $73,220 for Harrisburg, a city of 81,702 population, which collects the ashes with city forces; and $87,999 for Chester, a city of 65,649 population, where the service is contracted for.

# Highway Safety Conference

A national conference on Street and Highway Safety met in Washington, December 15th and 16th at the invitation of Secretary Hoover, nearly a thousand persons attending. Reports were presented by a number of committees that had been appointed last Spring, and these were combined into a general report which was presented to the conference on the second day, discussed and adopted. The report is divided under the several heads of "Legislative Principles," "Administrative and Regulatory Principles," "City Planning and Zoning," "Street and Highway Construction," "The Motor Vehicle" and "Conduct of Drivers and Pedestrians," and suggestions for co-operative work.

The features of the report of most interest to readers of PUBLIC WORKS are those under the heading of "City Planning and Zoning" and "Street and Highway Construction." Under the first head it was recommended that each community study its own special problems presented by grade crossings of streets and highways with each other and with railroads or rapid transit lines, with a view to eliminating such crossings as present the most danger. Problems of classifying traffic and providing suitable and adequate facilities for each class; locating traffic-originating centers and development of outlying areas with a view to straightening main traffic arteries and locating them at the most suitable intervals; best utilization of local topography to create bypass highways and belt highways so as to di-

vert through traffic from congested districts; and control of sub-divisions to avoid conditions now causing congested traffic, were some of the city planning problems emphasized. Other subjects considered were: Parking and day storage of automobiles; details of streets, such as width, corner radius, etc.; planning industrial and business sub-centers and satellite communities; adapting zoning to street facilities and vice versa; locating playgrounds and schools to minimize dangers to children using them, and coordinating all its efforts in a comprehensive traffic and thoroughfare plan.

Under the heading of "Street and Highway Construction" the principal features considered were roadway width, right of way, parking spaces, grades, curves, cross-section, guard rail, clear view, street intersections, bridges, detours, maintenance and snow removal, marking speed zones, signs and signals, railroad crossing protection, street and highway surface markings, and lighting.

Under the various headings the opinions were expressed that the roadway of every highway should be wide enough for at least two lines of traffic, the pavement of every city street for at least three lines without street-cars and four lines with street-cars, 9 feet being the minimum width of lane for motor vehicles. Rural highways should be provided with parking spaces, either continuously or at intervals of 300 feet. If possible, 6 per cent should be the maximum grade for any thoroughfare of primary importance, and 300 feet the minimum radius; while extreme grade and curve should not be combined at any one point. The cross-section of the pavement should be as flat as drainage conditions will permit. The pavement should be widened and banked at curves and provided with transition curves. Guard railings of substantial type should be erected along the edge of embankments. A clear view of approaching vehicles for at least 300 feet should be provided at all points on primary highways; these involving control of advertising signs, trees and shrubs, sloping banks, etc., on private as well as on public property. At street intersections the grade of each street should be maintained if possible. The radius of curves at the curb lines should not be less than 15 feet. Every bridge should be at least 22 feet wide if on an improved highway or street, and suitable provision be made for pedestrians either by sidewalks or frequent safety zones outside the roadway.

Abundant signs should be provided giving local speed limits, cautionary or stop signals, direction and distance signs. The colors recommended were red for "stop," green for "proceed" and yellow for "caution," white letters to be used on red or green background and black on the yellow. These three colors should not be used for any other signs, but distance and direction signs should be black and white. The yellow sign should be used for sharp curves, steep descending grades, narrow bridges and other danger points. Railroad crossings at grade should be safeguarded in every reasonable way. Sharp curves, abrupt changes of grade, roughness in the pavement and other devices near crossings diverting the attention of the driver are not considered advisable. The white center line on curves, at hill crests and irregular intersections on highways are recommended, and no parking permitted opposite these white lines; but these lines should not be used on straight level sections, black center lines being preferable on such sections. Curbs, poles and other objects near the roadway should be painted white; while obstructions in the center should be striped diagonally white and black. The lighting of state hghways is advisable wherever it is financially practicable. Flood lighting of traffic officers is recommended.

## Highway Work in St. Paul

At the beginning of the year 1924, according to the annual report of the Commissioner of Public Works, which has recently been made public, the city of St. Paul, Minn., had 384 miles of streets that were graded only, 32 miles of macadam roads, 12.4 miles of gravel roads and 148 miles of paved streets. These figures show that exactly one-third of the streets of the city have received some surface treatment other than grading, and that only one-fourth are paved with material better than macadam or gravel.

Paving delay is attributed chiefly to certain provisions of the charter. Under the amendment to the charter adopted in 1920, the city has the power of assessing up to but not exceeding the cost of a 12-foot strip of pavement on each side of the street, and the balance of the paving must be paid by the city. It was originally contemplated that the city's amount would be raised by a wheelage tax equivalent to the state automobile license tax. During 1923 approximately $110,000 was raised by the wheelage tax and much of this was required for financing non-assesable portions of pavement laid during 1922; as a result of which a comparatively small amount of pavement was laid in 1923.

To remedy this condition a charter amendment was passed in 1923 which provides $400,000 each year from the general fund for the purpose of paying for the non-assessable portion of pavements, which includes intersections as well as the excess above the 12-foot strip on each side of the street; a part of the appropriation to be used also in constructing trunk sewers. This permitted a considerable amount of paving work to be done in 1924.

Mr. George M. Shepard, chief engineer of the Department of Public Works, made a study of the relative economy of various types of pavement and reported that between the years 1914 and 1923 the price of cement had increased 92%, crushed rock or gravel 62%, sand 50%, creosoted wood blocks 108%, vitrified brick 50%, sandstone block 80%, but asphalt less than 3%. He stated that "it may easily be shown that the interest on the difference in cost between two types of pavement will furnish maintenance for the lower

priced type, to say nothing of the extra amount necessary to retire the difference in first cost between a high and low priced pavement during a life of, say, twenty years." He reported that the asphalt plant of the city had been used at its full capacity and had proved a valuable asset to the city as a regulator of contractors' bids and that provision had been made for purchasing and installing a new and more up-to-date plant.

## Impure Water for Concrete Mixing

One of the matters that has been investigated by Professor Duff A. Abrams, of the Research Laboratory of Lewis Institute, is that of the effect of using impure water for mixing concrete. Professor Abrams has recently made public the conclusions from about 6,000 tests as well as detailed descriptions of the tests themselves. The waters used included sea and alkali waters, bog waters, mine and mineral waters, waters containing sewage and industrial wastes, and solutions of common salt. The conclusions, as stated in his paper, are 33 in number, the more important of which may be summarized as follows:

Most of the waters gave good results in both concrete and mortar. This seems to be due to the fact that the quantity of injurious substance present is quite small. He accepted as satisfactory a water which gave concrete with strength ratios above 85 per cent. The only waters which failed to do so were certain acid waters, lime soak from tanneries, refuse from a paint factory, some mineral waters from Colorado and water containing over 5 per cent of common salt.

"The quality of a mixing water is best measured by the ratio of its 28-day concrete or mortar strength to that of similar mixes with fresh water. . . . . The time-of-setting tests appears to be an unsafe guide as to the suitability of a water for mixing concrete." Bog waters seldom give a strength ratio below 90 per cent. Sulphate waters produced little or no ill effects until an $SO_4$ concentration of about 1 per cent was reached.

Sea water cured in a moist room gave stronger concrete than fresh water up to 7 days, but at 28 days and over the strength ratio ranged from 80 to 88 per cent. (In spite of the satisfactory strength results, it seems unwise to use sea water in reinforced concrete construction, particularly in the tropics, on account of danger of corrosion of the reinforcement.) Salt water from Great Salt Lake, which contains about 20 per cent sodium chloride, gave strength ratios of only 65 to 77 per cent. Water from Devil's Lake, N. D., and Medicine Lake, S. D., gave results similar to sea water.

The use of salt water for lowering the freezing point during cold weather should not be permitted, for while 5 per cent salt lowers the freezing point about six degrees, it reduces the strength of concrete about 30 per cent.

Water from drains and streams in sulphate districts gave no lower strength ratios than about 90 per cent. Mine and mineral waters gave good results, with the exception of a carbonated mineral water from Colorado. Pumpage waters from coal and gypsum mines gave good results.

Water containing sanitary sewage gave essentially the same strength as fresh water. That from Bubbly Creek, draining the Chicago stockyards and giving off an offensive odor, gave 100 per cent. strength ratios for all ages, mixes and consistencies. The same was true of brewery and soap works wastes, while waste from a gas plant and that from a corn products factory gave strength ratios between 90 and 100 per cent.

Water containing refuse from oil refineries gave erratic results, tannery wastes gave ratios as low as 80 per cent and paint factory wastes between 80 and 90 per cent.

Professor Abrams called attention to the fact that "a comparatively slight increase in *quantity* of mixing water produced a greater reduction in concrete strength than that caused by the use of the most *polluted* water that is ordinarily encountered."

While most of the above statements are given as referring to concrete, it is also stated that the effect on the compressive and tensile strength of 1:3 standard sand mortar was generally similar to that on the compressive strength of concrete.

None of the impure waters caused unsoundness of cement when subjected to standard test over boiling water. The effect of sugar and similar compounds was not studied, but earlier tests have shown that these compounds are detrimental and must be avoided.

## San Diego Approaches Water Supply Limit

A leading hydraulic engineer of the country is reported to have stated that the city of San Diego, Calif., has not practically available a supply of water sufficient to provide for a population greater than that which it is expected to reach within the next fifteen to twenty years. If the city continues at its present rate of growth for that period of time, it will, if this statement is correct, then be up against the alternative of either submitting to an absolute and imperative termination of all increase in population, or else educating its people to use less water per capita. As the present population of the city is about 100,000 and the present consumption of water is about 14,000,000 gallons a day, there would seem to be considerable possibilities in the latter alternative.

The problem is further complicated, however, by the fact that a naval base is being developed in San Diego Harbor which will require fresh water, and for this reason the Federal Government may be induced to cooperate.

Only one suggestion, we believe, has been made for increasing the water supply. (We do not consider the distilling of water from the Pacific, as this, while possible, is decidely imprac-

vert through traffic from congested districts; and control of sub-divisions to avoid conditions now causing congested traffic, were some of the city planning problems emphasized. Other subjects considered were: Parking and day storage of automobiles; details of streets, such as width, corner radius, etc.; planning industrial and business sub-centers and satellite communities; adapting zoning to street facilities and vice versa; locating playgrounds and schools to minimize dangers to children using them, and coordinating all its efforts in a comprehensive traffic and thoroughfare plan.

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Water containing sanitary sewage gave essentially the same strength as fresh water. That from Bubbly Creek, draining the Chicago stockyards and giving off an offensive odor, gave 100 per cent. strength ratios for all ages, mixes and consistencies. The same was true of brewery and soap works wastes, while waste from a gas plant and that from a corn products factory gave strength ratios between 90 and 100 per cent.

Water containing refuse from oil refineries gave erratic results, tannery wastes gave ratios as low as 80 per cent and paint factory wastes between 80 and 90 per cent.

Professor Abrams called attention to the fact that "a comparatively slight increase in *quantity* of mixing water produced a greater reduction in concrete strength than that caused by the use of the most *polluted* water that is ordinarily encountered."

While most of the above statements are given as referring to concrete, it is also stated that the effect on the compressive and tensile strength of 1:3 standard sand mortar was generally similar to that on the compressive strength of concrete.

None of the impure waters caused unsoundness of cement when subjected to standard test over boiling water. The effect of sugar and similar compounds was not studied, but earlier tests have shown that these compounds are detrimental and must be avoided.

## San Diego Approaches Water Supply Limit

A leading hydraulic engineer of the country is reported to have stated that the city of San Diego, Calif., has not practically available a supply of water sufficient to provide for a population greater than that which it is expected to reach within the next fifteen to twenty years. If the city continues at its present rate of growth for that period of time, it will, if this statement is correct, then be up against the alternative of either submitting to an absolute and imperative termination of all increase in population, or else educating its people to use less water per capita. As the present population of the city is about 100,000 and the present consumption of water is about 14,000,000 gallons a day, there would seem to be considerable possibilities in the latter alternative.

The problem is further complicated, however, by the fact that a naval base is being developed in San Diego Harbor which will require fresh water, and for this reason the Federal Government may be induced to cooperate.

Only one suggestion, we believe, has been made for increasing the water supply. (We do not consider the distilling of water from the Pacific, as this, while possible, is decidely imprac-

ticable.) This is to bring water to San Diego from the Colorado river. This is far from being a simple proposition, but if it is a matter of life or death for the city of San Diego, it may yet be developed. The point suggested for taking the water from the river lies 180 miles east of San Diego and involves pumping the water to an elevation of 900 to 1,000 feet above the source and carrying it through the mountains by a tunnel 25 miles long, from which it would be discharged into a reservoir on the San Diego river. Power for pumping would probably be obtained from the dam which it is proposed to build across the Colorado river. Nearly 10 miles of the line would be laid through the drifting sand hills which, as formerly described in PUBLIC WORKS, has presented so many difficulties to the Highway Department by the continual movement of the sand hills across the desert.

A preliminary rough estimate of the cost indicates that this would be between $15,000,000 and $20,000,000. It is contemplated to deliver through the system a maximum of 2,000-second-feet of water, and interest, depreciation and maintenance is figured at 2.3c per thousand gallons delivered, pumping at 4.5c, giving a total of 6.8c. At the beginning, when not more than 100-second-feet are being delivered, the cost per thousand gallons would be approximately 10c.

The San Diego chapter of the American Association of Engineers is advocating that the city raise funds for a preliminary survey and investigation of the feasibility of this plan.

## City Managers' Code of Ethics

The City Managers Association has adopted a code of ethics prepared by a committee composed of I. E. Carr, Louis Brownlow, C. W. Koiner and Frank D. Danielson, which embodies the high moral standard which city managers, with very few exceptions, have individually set for themselves and lived up to with praiseworthy fidelity. The same code, almost without change, would apply to and should be lived up to by city engineers and other officials in charge of public works. The code is as follows:

1. The position of city manager is an important position and an honorable position and should not be accepted unless the individual believes that he can serve the community to its advantage.

2. No man should accept a position of city manager unless he believes in the council manager plan of government.

3. In personal conduct a city manager should be exemplary and he should display the same obedience to law that he should inculcate in others.

4. Personal aggrandizement and personal profit secured by confidential information or by misuse of public time is dishonest.

5. Loyalty to his employment recognizes that it is the council, the elected representatives of the people, who primarily determine the municipal policies, and are entitled to the credit for their fulfillment.

6. Although he is a hired employee of the council, he is hired for a purpose—to exercise his own judgment as an executive in accomplishing the policies formulated by the council, and to attain success in his employment he must decline to submit to dictation in matters for which the responsibility is solely his.

7. Power justifies responsibility and responsibility demands power, and a city manager who becomes impotent to inspire support should resign.

8. The city manager is the administrator for all the people and in performing his duty he should serve without discrimination.

9. To serve the public well, a city manager should strive to keep the community informed of the plans and purposes of the administration, remembering that healthy publicity and criticism are an aid to the success of any democracy.

10. A city manager should deal frankly with the council as a unit and not secretly with its individual members, and similarly should foster a spirit of cooperation between all employees of the city's organization.

11. No matter how small the governmental unit under his management, a city manager should recognize his relation to the larger political subdivisions and encourage improved administrative methods for all.

12. No city manager should take an active part in politics.

13. A city manager will be known by his works, many of which may outlast him, and regardless of personal popularity or unpopularity, he should not curry favor or temporize but should in a far-sighted way aim to benefit the community of today and of posterity.

## Highway Work in Pennsylvania

The Pennsylvania Department of Highways has published a number of figures summarizing the work done by it during 1924. It constructed or resurfaced 567 miles of reinforced concrete, 11 miles of bituminous pavement on a concrete base, 112 miles of bituminous macadam resurfacing, and 518 miles of stone road resurfacing. It also laid 1½ million square yards of patching. It widened 900 miles of earth roads, gave bituminous surface treatment to 1,886 miles of macadam and oiled 800 miles of earth roads. It eliminated 20 grade crossings and reconstructed four overhead crossings, and began work on eliminating nineteen additional grade crossings.

It erected 173½ miles of cable guard rail and 10,800 cast-iron danger and direction signs. Six hundred miles of traffic line was painted and 310,200 poles were whitewashed.

In the various work done it used 1,802,000 barrels of cement, 2,418,000 tons of stone, 787,800 tons of sand and 14,538,200 gallons of bituminous material. In transporting the material 2,360 trucks were used, which traveled 6,200,000 miles during the season.

# Recent Legal Decisions

### LIMITATION OF POWER TO PASS ZONING ORDINANCES

The New York Appellate Division holds, Barker vs. Switzer, 205 N. Y. Supp. 108, that zoning ordinances, when ordained in pursuance of a legislative grant of power to a municipality and operating without discrimination between property owners, are a lawful exercise of police power. But the power has its limitations and the enabling statute itself sets forth guides by which the municipality is bound.

A zoning ordinance prohibiting the erection in sections of residential districts of dwelling or tenement houses for more than ten families to the acre is held invalid as exceeding the power conferred by New York General City Law, section 20, subd. 24 and 25, to "regulate and limit the height and bulk of buildings hereafter erected and to regulate and determine the area of yards, courts and other open spaces, and for said purposes to divide the city into districts."

### RELATIVE RIGHTS OF MUNICIPAL CORPORATION AND PUBLIC UTILITIES AS TO OPERATION OF PLANTS

The Circuit Court of Appeal, Fourth Circuit, holds, Hill v. Elizabeth City, 298 Fed. 67, that the continuation of the service of a light and water company and the acceptance of it by the city after the expiration of an express contract implies a contract of indefinite duration, terminable upon reasonable notice, either by the city or by the company, at such time and under such circumstances as may be consistent with the duty both owe to the inhabitants of the city.

This indefinite renewal of the contract does not, it is held, confer any right on the company to enjoin the city from constructing its own plant. The general rule is that the franchise to a private corporation, or its contract to supply light and water or other public utility to a city, does not prevent the city from constructing and operating like public utilities of its own, unless the franchise or contract expresses or clearly implies an exclusive right.

### MATERIALMEN'S RIGHTS UNDER GOVERNMENT CONTRACTOR'S BOND

In an action by a materialman on a government road contractor's bond, the action must be commenced within one year after the performance and final settlement of the contract. The Court of Appeals of District of Columbia holds, United States Fidelity & Casualty Co. v. United States, 298 Fed. 365, that the settlement of a road contract dated from the approval by the Board of Yards and Docks of a final voucher for payment in full under the contract, "without the assessment of damages for delay." Up to that time damages were actually due to the government from the contractor, and this was the first authoritative remission of the same.

The surety was held not liable to materialmen for materials for new roads connecting the road first contracted for with other points not contemplated by the original contract. Such additional roads were not changes in detail covered by the government's reservation to change the contract, plans and specifications, this reservation permitting only of changes not so extensive and material as to amount to a departure from the original contract.

### HIGHWAY DISTRICT'S POWER OF TAXATION

The Circuit Court of Appeals, United Circuit, holds, Kimana Highway Dist. v. Oregon Short Line, 298 Fed. 431, that an Idaho highway district is not a political municipality, and is not created for general government purposes. It is an entirely different kind of municipality from a city, town or village. It is created for a special purpose, the assessment of property for the improvement of the highways within the district, and its power to tax is not unlimited. It is therefore held that a bond issue for the construction of a highway mainly in uninhabited country, and parallel with a railroad, which would serve no substantial local need and about 95 per cent. of the cost of which would be taxable on the railroad's property, was arbitrary and, in effect confiscatory.

### CITY ENGINEER'S CLASSIFICATION OF EXTRA WORK AT UNIT PRICES

Where the parties to a construction contract agreed that the city's engineer had a right to order extra work and that it was his duty to classify it when performed, at unit prices if capable of such classification, and if not, at cost plus 10 per cent, the New York Appellate Division holds, E. E. Smith Contracting Co. v. City of New York, 204 N. Y. Supp. 289, that the contractor was bound by the engineer's classification under unit prices, in the absence of fraud or bad faith, or an erroneous construction of the contract.

### PAVING CERTIFICATES PROPERLY EXECUTED BY MAYOR IN OFFICE

The Texas Court of Civil Appeals holds, Holt v. Uvalde Co., 258 S. W. 285, that paving certificates executed by the mayor in office at the time are properly executed although the certificates were authorized by a mayor whose terms of office had subsequently expired.

### "WORKING DAYS" AND HOLIDAYS WITHIN PAVING CONTRACT

The Missouri Court of Appeals holds, Byrne Real Estate Co. v. Welsh, 258 S. W. 743, that where a paving contract was to be completed within 120 working days, in determining whether an extension ordinance was passed within the 120 working days, the Monday following Columbus Day, which fell upon Sunday, was a holiday within Rev. St. 1919, Sec. 5848, and was not to be treated as a working day.

### ORDER ESTABLISHING ROAD HELD VOID FOR INDEFINITENESS

The Arkansas Supreme Court holds, Burns v. Harrington, 257 S. W. 729, that an order of a county court was void for indefiniteness in which there was no reference to any survey, and it did not appear that the road had been definitely marked or desig-

nated, or any indication how or where the lands of the respective owners would be crossed except that the terminus of the new road would intersect the county road at a specified place.

#### INVALIDITY OF ORDINANCE REQUIRING CONSTRUCTION OF VIADUCT

The Tennessee Supreme Court holds, City of Knoxville v. Southern, 258 S. W. 143, that a city could not require ramps to be constructed by a railroad in connection with its viaduct where there was no public necessity for their construction; and where the ramps were essential parts of the ordinance requiring the construction of the viaduct, the ordinance was void.

#### ROAD IMPROVEMENT DISTRICT NOT SUBJECT TO GARNISHMENT PRIOR TO COMPLETION OF IMPROVEMENT

The Arkansas Supreme Court holds, Newell Contracting Co. v. Elkins, 257 S. W. 54, that a road improvement district is not subject to garnishment prior to the completion of the improvement to construct which it was created.

#### TAX BILLS INVALIDATED WHERE CONTRACT ALLOWED GREATER TIME FOR COMPLETION THAN ADVERTISEMENT FOR BIDS

Where the advertisement for bids for the construction of a sewer stated that it would be required to be completed within four months, it was held, Koch v. Inter-River Drainage District of Missouri, (Mo. App.) 257 S. W. 176, that a provision in the contract allowing eight months in which to do the work was a legal fraud and invalidated the tax bills issued in payment of the work.

#### ROAD CONTRACTOR HELD NOT LIABLE FOR MATERIAL FURNISHED SUBCONTRACTOR WHO WAS INDEPENDENT CONTRACTOR

Where the contract for the construction of a road was sublet to a construction company, over which the principal contractor had no control and did not hire or discharge its men, the construction company being responsible only to the principal contractor for results, it was held, Mink Bros. v. Gilloiz, (Mo. App.) 256 S. W. 516, that the construction company was an independent contractor, and the principal contractor was not liable for gasoline, oil, work and material furnished to the construction company.

#### PRINCIPAL CONTRACTOR HELD LIABLE FOR MATERIAL FURNISHED SUBCONTRACTOR UNDER ARKANSAS ACT

The Arkansas Supreme Court holds, Kotchtitzky v. Magnolia Petroleum Co., 257 S. W. 48, that the principal contractor for the construction of a drainage ditch for a district organized under Act No. 279 of Acts of 1909 was impliedly liable under the statute for material furnished to a subcontractor of a portion of the work, as if the contract had expressly provided therefor.

#### NOTICE IN PAVING RESOLUTION HELD NOT TO INCLUDE NOTICE OF WATER AND SEWER CONNECTIONS

A street paving resolution recited that "the material with which the street is to be paved shall be any of that which is set forth in the plans and specifications prepared by the city engineer, which have been adopted and are now on file with the city clerk." The plans and specifications on file for such paving project provided for water and sewer connections, the expense to be paid by the abutting owners. The city, in an action to charge a lot owner with the cost of connecting his premises with the city's sewer and water mains, contended that the reference in the resolution was sufficient notice to abutting owners of what was contained in the plans and specifications. The Mississippi Supreme Court held, City of Jackson v. Greaves, 98 So. 337, that water and sewer connections are special improvements separate and distinct from a paving project, and therefore said notice to the abutting owners was insufficient as notice that the municipality sought to charge them with the cost of such water and sewer connections.

#### COUNCIL'S DUTY TO RESCIND ACCEPTANCE OF IMPROVEMENT ON DISCOVERING WORTHLESS CONDITION OF WORK

The Indiana Appellate Court holds, Blain v. City of Delphi, 139 N. E. 339, that where paving contractors have made a false affidavit that they have completed the work according to plans and specifications, the city council has no right to accept the improvement, even after the contractors have executed a bond conditioned for the repair of such parts of the improvement as may show evidence of disintegration within five years. After discovery of the worthless condition of the work, it is the council's duty to rescind the acceptance made and to refuse to make any final assessment until the work has been performed according to the contract.

#### AUTHORITY TO CONSTRUCT WATERWORKS DOES NOT AUTHORIZE LAYING PIPES TO CONNECT WITH OTHER WATERWORKS

The Louisiana Supreme Court holds, Young v. Bossier City, 98 So. 45, that authority to taxpayers to issue bonds for the construction of waterworks for the village did not authorize the use of the proceeds to lay pipes and connect them with the waterworks system of another municipality, the Louisiana Constitution providing that "no bonds shall be issued for any other purpose than that stated in the proposition to the taxpayers."

#### CONTRACT TO PAY CONTRACTOR WITH CITY BONDS MAY BE ENJOINED IF COST OF IMPROVEMENT THEREBY INCREASED

The Nebraska Supreme Court holds, Ledwith v. City of Lincoln, 193 N. W. 763, that where the city charter does not require the sale of bonds to the highest bidder, the city when authorized to issue and sell bonds for a public improvement, may, with consent of the contractor, deliver to him the bonds at par in payment of the contract price. But a provision in a notice to contractors that the city reserves the right to pay in warrants or bonds is unenforceable except with consent of the contractor and if it will increase the cost by preventing competition by limiting the bids to those able to do the work on their own financial responsibility, the city should be enjoined from making the contract.